Short-Run Effects of Employment Growth on Travel Time: An Empirical Analysis Using U.S. Military Troop Movements

Geoff Morrison
C.-Y. Cynthia Lin

ARE Workshop
Apr. 26, 2013
Outline

UC Davis-ITS
Motivation
Methodology
DD(D) Results
IV Results
Limitations of Study
Policy Implications
ITS-Davis

~100 grad students
~25 professors
collaborations with energy companies, automakers, policymakers

Main research threads

electric vehicles, bioenergy, hydrogen, NG state/national transportation policy (e.g. LCFS, FE standards)
global energy systems modeling
consumer choice
bicycle research
lifecycle assessment of fuels, vehicles, pavement
Negative Externalities of Traffic Congestion

- Health effects (Volk et al., 2011)
- Discouraged economic growth (Hymel, 2009)
- Reduced economies of agglomeration (Hymel, 2009)
- Psychological burden of travel (Krueger et al., 2011)
- Traffic accidents (Downs, 2004)
- Time cost (Lomax et al., 2011)
## Incident vs. Recurrent Congestion

### Incident
- Severe weather (+)
- Traffic accidents (+)
- Special events (+)
- Change in modes/routes (-/+)

### Recurrent
- Vehicle ownership (+/-)
- Travel preferences (+/-)
- Size & spatial dimension of city (+/-)
- Geo-demographics (+/-)
- Two-worker households (+/-)
- Absolute employment levels (+/-)
- Rate of change of employment (+/-)
Research Questions

When a community experiences a rapid and unanticipated employment growth shock, what is the short-run impact on travel time to work?

What is the economic travel time “cost” to the community?
Why employment growth not population growth?

- 20% of all trips are for commute
- 27% of vehicle miles travelled are for commute
- Average commuter is stuck in 34 hours of congestion/year
- Level of employment determines peak-hour traffic
Two Potential Endogeneity Issues

Rapid employment growth $\rightarrow$ travel time

1. Simultaneity
   New businesses may not locate in a city if travel times are high. Thus, travel time influences employment growth.

2. Omitted Variable
   The cycle of infrastructure planning and build-out is difficult to quantify. If city planners expect a city to grow, they will allocate resources to preemptively address the growth.
Military Troop Relocations

Number of New Military Employees

- <10,000
- 10K - 20K
- 20K - 30K
- >30K

Forts:
- Fort Lewis-McChord
- Fort Carson
- Fort Riley
- Fort Sill
- Fort Bliss
- Fort Sam Houston
- Fort Knox
- Fort Benning
- Eglin AFB
- Redstone Arsenal
- Camp Lejeune
- Fort Bragg
- Fort Meade
- Fort Lee
- Aberdeen Proving Grounds
- Fort Belvoir
History of Base Realignment and Closure (BRAC)

1960s: SecDef McNamara closed 60 bases w/o approval from congress

1977: Public Law 95-82 required congressional participation in process

1977-1988: no base closures; DoD recommendations ignored

Late 1980s: End of Cold War decreased DoD budget, Armey Goldwater Act

1988+: Four BRACs rounds with 125 major bases, 225 minor bases, 145 bases ‘realigned.’

Savings estimated at ~$20 billion per year
Exogenous Shock of 2005 BRAC

2005 BRAC

- Closed 29 bases
- Relocated 123,000 troops to 57 other bases
- Troops required to be re-located between 2006-2011

<table>
<thead>
<tr>
<th>Action</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Congress authorizes DoD to explore options for a 2005 BRAC</td>
<td>Dec. 28, 2001</td>
</tr>
<tr>
<td>President appoints 8-member BRAC commission to oversee BRAC process</td>
<td>Apr. 1, 2005</td>
</tr>
<tr>
<td>DoD submits recommendations of base closures to BRAC commission</td>
<td>May 16, 2005</td>
</tr>
<tr>
<td>BRAC commission recommendations sent to congress</td>
<td>Sept. 8, 2005</td>
</tr>
<tr>
<td>President approves BRAC base realignment list</td>
<td>Nov. 7, 2005</td>
</tr>
<tr>
<td>Troop relocations begin</td>
<td>Jan. 1, 2006</td>
</tr>
<tr>
<td>Deadline for completion of troop movements</td>
<td>Sept. 30, 2011</td>
</tr>
</tbody>
</table>
Beltsville faces BRAC traffic surge this fall

By Robert Thomas, Published: April 16, 2011

On a map, Beltsville might seem like an ideal spot for one of the U.S. military’s base consolidation will be a Capital Beltway traffic study masks daily misery on the roads, experts say

Army News

Solutions sought for BRAC-related traffic

A report from the National Academy of Sciences calls for projects to be fast-tracked to help with the expected gridlock

By Jim Tusa - Staff writer
Posted - Saturday Feb 19, 2011 8:22:51 EST

Brace Yourself For New Brac Traffic Patterns And More Congestion

If you thought the commute on last week’s “Terrible Traffic Tuesday” was hellacious, it was just a harbinger or a precursor of things to come on area roads. Better brace yourself for the full brunt of the BRAC impact on area roads in the Greater Washington region. Some area residents and drivers worry that the new jobs will spawn a vast influx of vehicles onto area roads,” forewarn area transportation departments and AAA Mid-Atlantic.

As a result of the 2005 Pentagon Base Realignment and Closure (BRAC) law, more than 35,000 military service personnel, civilian employees, and defense contractors will be redeployed and relocated to new sites in the Washington metro area by the September 15th deadline. And that’s just the beginning, says AAA Mid-Atlantic. Expect upwards of 20,000 additional personnel to converge on the Washington suburbs by 2015, bringing the total count to more than 82, 000 redeployed workers on area roads and transit systems, plus thousands of family members in new homes and kids in area schools.
Two Potential Endogeneity Issues

Rapid employment growth $\rightarrow$ travel time

1. Simultaneity
   
   New businesses may not locate in a city if travel times are high. Thus, travel time influences employment growth.
   
   Hymel (2009) demonstrates that impact of congestion on employment has a 10+ year lag. We’re measuring short-run effects.

2. Omitted Variable
   
   The cycle of infrastructure planning and build-out is difficult to quantify. If city planners expect a city to grow, they will allocate resources to preemptively address the growth.
   
   BRAC occurred with little warning to the surrounding communities.
Dataset

- **American Community Survey**
  - Person-level data on travel time to work, mode to work, socio-economics, demographics, and more
  - Monthly samples to produce annual estimates
  - Replacement of “Long-form” of census
  - ~3 million observations per year (10% per 10 years)
  - We use 2000, 2005-2010 data (2001-2004 not avail.)

- **Other Data**
  - DoD Base Structure Reports
  - GAO, 2009
## Description of Data

<table>
<thead>
<tr>
<th>Variable</th>
<th>Min</th>
<th>Max</th>
<th>Military in BRAC-affected Areas</th>
<th>US Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mean (std error)</td>
</tr>
<tr>
<td>Commute Travel Time 2000-2005</td>
<td>0</td>
<td>188</td>
<td>20.43 (16.16)</td>
<td>23.81 (23.17)</td>
</tr>
<tr>
<td>Commute Travel Time 2006-2010</td>
<td>0</td>
<td>188</td>
<td>22.52 (17.32)</td>
<td>23.58 (22.13)</td>
</tr>
<tr>
<td>Worker density (workers/sq-km)</td>
<td>5.66</td>
<td>193.3</td>
<td>770.2 (39.20)</td>
<td>2040.3 (497.40)</td>
</tr>
<tr>
<td>Education</td>
<td>0</td>
<td>16</td>
<td>7.61 (1.82)</td>
<td>7.36 (2.31)</td>
</tr>
<tr>
<td>Family members</td>
<td>0</td>
<td>1</td>
<td>2.90 (1.49)</td>
<td>2.84 (1.60)</td>
</tr>
<tr>
<td>Female</td>
<td>0</td>
<td>1</td>
<td>0.14 (0.35)</td>
<td>0.47 (0.50)</td>
</tr>
<tr>
<td>Immigration status</td>
<td>0</td>
<td>1</td>
<td>0.10 (0.29)</td>
<td>0.17 (0.37)</td>
</tr>
<tr>
<td>Num. riders in car</td>
<td>0</td>
<td>9</td>
<td>1.08 (0.52)</td>
<td>0.99 (0.70)</td>
</tr>
<tr>
<td>Hours worked</td>
<td>0</td>
<td>99</td>
<td>53.23 (14.50)</td>
<td>39.46 (12.50)</td>
</tr>
<tr>
<td>Vehicles per family member</td>
<td>0</td>
<td>6</td>
<td>1.15 (0.61)</td>
<td>1.20 (0.72)</td>
</tr>
<tr>
<td>Married</td>
<td>0</td>
<td>1</td>
<td>0.71 (0.45)</td>
<td>0.53 (0.50)</td>
</tr>
<tr>
<td>Population density (people/sq-km)</td>
<td>11.2</td>
<td>340.8</td>
<td>86.70 (70.90)</td>
<td>402.60 (842.10)</td>
</tr>
<tr>
<td>Lives in rural area</td>
<td>0</td>
<td>1</td>
<td>0.16 (0.36)</td>
<td>0.15 (0.36)</td>
</tr>
<tr>
<td>Lives in urban area</td>
<td>0</td>
<td>1</td>
<td>0.13 (0.34)</td>
<td>0.15 (0.36)</td>
</tr>
<tr>
<td>Train density (train operators/sq-km)</td>
<td>0</td>
<td>0.36</td>
<td>0.015 (0.043)</td>
<td>0.32 (1.55)</td>
</tr>
<tr>
<td>Bus density (bus operators/sq-km)</td>
<td>0</td>
<td>0.67</td>
<td>0.047 (0.090)</td>
<td>0.91 (3.62)</td>
</tr>
<tr>
<td>Sample Size (weighted)</td>
<td>6,093 (631,802)</td>
<td></td>
<td>9.60E6 (9.81E8)</td>
<td></td>
</tr>
</tbody>
</table>
Graphically

\[ DD = [(\bar{Y}_1 | D=1) - (\bar{Y}_0 | D=1)] - [(\bar{Y}_1 | D=0) - (\bar{Y}_0 | D=0)] \]
Geographic Set-up

DD(D) Models
1. DD-1: Within PUMA military vs. civilians
2. DD-2: Outside PUMA military vs. military
3. DDD-1: Both comparison groups

1. DD-3: Adjacent PUMA civilians vs. civilians
2. DD-4: Outside PUMA civilians vs. civilians
3. DDD-2: Both comparison groups
DD(D) Models

\[ TT_{irt} = \alpha + \beta_1 \text{post}_t + \beta_2 \text{military}_{irt} + \beta_3 \text{post} \times \text{military}_{irt} + \beta_4 \text{post} \times \text{BRAC}_{\text{Affected}_{irt}} \]
\[ + \beta_5 \text{military} \times \text{BRAC}_{\text{Affected}_{irt}} + \delta \text{post} \times \text{military} \times \text{BRAC}_{\text{Affected}_{irt}} \]
\[ + \varphi_r + \theta_t + X_{irt}'\gamma + \varepsilon_{irt} \]

Variables
TT – Travel Time (min.)
Post – after 2005
Treated – BRAC-affected individual
Φ – State Fixed Effects
Θ – Year Fixed Effects
Γ – control variables

Indices
i – person
r – region
t – year
## DD(D) Results

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>DD-1 Drivers Only</th>
<th>Full Model</th>
<th>DD-1 Drivers Only</th>
<th>Full Model</th>
<th>DD-1 Drivers Only</th>
<th>Full Model</th>
<th>DD-2 Drivers Only</th>
<th>Full Model</th>
<th>DD-1 Drivers Only</th>
<th>Full Model</th>
<th>DD-2 Drivers Only</th>
<th>Full Model</th>
<th>DD-3 Drivers Only</th>
<th>Full Model</th>
<th>DD-4 Drivers Only</th>
<th>Full Model</th>
<th>DDD-2 Drivers Only</th>
<th>Full Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interaction Effect</td>
<td>0.63*** 0.83*** 4.08*** 4.89*** 0.87*** 0.92***</td>
<td>0.617*** 0.615*** 3.076*** 2.894*** 0.263*** 0.411***</td>
<td>Std. Error</td>
<td>(0.0738) (0.0736) (0.0976) (0.103) (0.0868) (0.088)</td>
<td>(0.0291) (0.0287) (0.0576) (0.203) (0.0367) (0.0367)</td>
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<td></td>
</tr>
<tr>
<td>Control Variables†</td>
<td>Yes Yes Yes Yes Yes Yes</td>
<td>Yes Yes Yes Yes Yes Yes</td>
<td>State Fixed Effects</td>
<td>Yes Yes Yes Yes Yes Yes</td>
<td>Yes Yes Yes Yes Yes Yes</td>
<td>Year Fixed Effects</td>
<td>Yes Yes Yes Yes Yes Yes</td>
<td>Yes Yes Yes Yes Yes Yes</td>
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<td></td>
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</tr>
<tr>
<td>Obs. (millions)</td>
<td>3.9 4.2 0.63 0.67 12.3 13.6</td>
<td>9.3 9.9 0.63 0.67 26.7 29.2</td>
<td>R-squared</td>
<td>0.589 0.566 0.636 0.599 0.56 0.539</td>
<td>0.567 0.541 0.636 0.599 0.544 0.513</td>
<td></td>
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</tbody>
</table>

Standard errors in parentheses

†Control Variables:

- **Person-level:** age, age-squared, education level, income, female, vehicles per capita in household, years in the US, married, family size, family income, hours worked per week, number of riders in car
- **Land-use:** employee density of workplace (workers/sq-km), population density of workplace (people/sq-km), train density of workplace (train workers/sq-km), bus density of workplace (bus workers/sq-km), lives in urban environment

*** p<0.001
IV Regression Specification

\[ TT_{irt} = a + \beta_1 WD_{rt} + \beta_2 TT_{t-1,r} + \beta_3 IX_{irt} + \varphi_r + \theta_t + X_{irt}'\gamma + \varepsilon_{irt} \]

**Variables**
- \(TT_{irt}\) – Travel Time (min.)
- \(WD\) – Worker Density (workers/sq km)
- \(TT_{t-1}\) – Average Lagged Travel Time (min.)
- \(IX\) – Interaction terms, WD*Control Variables
- \(\Phi\) – Base Fixed Effects
- \(\Theta\) – Year Fixed Effects
- \(\Gamma\) – control variables

**Indices**
- \(i\) – person
- \(r\) – region
- \(t\) – year
## Instrumental Variable

<table>
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<tr>
<th>VARIABLES</th>
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<th>Interaction</th>
<th>No IX</th>
<th>Interaction</th>
<th>No IX</th>
<th>Interaction</th>
<th>No IX</th>
<th>Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Effect</td>
<td>0.00698****</td>
<td>0.0053****</td>
<td>0.00594****</td>
<td>0.00324****</td>
<td>0.0555****</td>
<td>0.05133****</td>
<td>0.0494****</td>
<td>0.0461****</td>
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<tr>
<td>Std. Error</td>
<td>(0.0005)</td>
<td>(0.1030)</td>
<td>(0.0004)</td>
<td>(0.0291)</td>
<td>(0.0004)</td>
<td>(0.0738)</td>
<td>(0.0004)</td>
<td>(0.1050)</td>
</tr>
<tr>
<td>Control Variables</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>State Fixed Effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Year Fixed Effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>First Stage F-Statistic</td>
<td>89.37</td>
<td>1387.29</td>
<td>63.85</td>
<td>799.20</td>
<td>10617.36</td>
<td>4959.60</td>
<td>7575.42</td>
<td>89.37</td>
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<tr>
<td>Observations</td>
<td>278036.00</td>
<td>278036</td>
<td>265161</td>
<td>265161</td>
<td>3129734</td>
<td>3129734</td>
<td>2935207</td>
<td>2935207</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.59</td>
<td>0.57</td>
<td>0.64</td>
<td>0.60</td>
<td>0.57</td>
<td>0.54</td>
<td>0.54</td>
<td>0.51</td>
</tr>
</tbody>
</table>

### Controls:
- **Person-level**: age, age-squared, education level, income, female, vehicles per capita in household, years in the US, married, family size, family income, hours worked per week, number of riders in car
- **Land-use**: employee density of workplace (workers/sq-km), population density of workplace (people/sq-km), train density of workplace (train workers/sq-km), bus density of workplace (bus workers/sq-km), lives in urban environment

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1
## Military - Economic Travel Time Costs

<table>
<thead>
<tr>
<th>Military Members</th>
<th>DD Calculations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data from IPUMS</strong></td>
<td></td>
</tr>
<tr>
<td>Avg income of military in BRAC-affected PUMAs ($2005)</td>
<td>$46,455</td>
</tr>
<tr>
<td>Avg hrs. worked / week by military in BRAC-affected PUMAs (hrs)</td>
<td>53.23</td>
</tr>
<tr>
<td>Avg weeks worked per year by military in BRAC-affected PUMAs (wks)</td>
<td>50.47</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Calculations</th>
<th>DD Calculations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hourly Income based on above ($/hr)</td>
<td>$17.29</td>
</tr>
<tr>
<td>DD/DDD coefficient on interaction term (avg effect) --low</td>
<td>0.63</td>
</tr>
<tr>
<td>DD/DDD coefficient on interaction term (avg treatment effect) -- high</td>
<td>4.90</td>
</tr>
<tr>
<td>IV coefficient on endogenous variables (workers/sq km) -- low</td>
<td></td>
</tr>
<tr>
<td>IV coefficient on endogenous variables (workers/sq km) -- high</td>
<td></td>
</tr>
<tr>
<td>Total cost of BRAC for all military commuters to BRAC bases ($/day) – Low</td>
<td>$30,225</td>
</tr>
<tr>
<td>Total cost of BRAC for all military commuters to BRAC bases ($/day) - High</td>
<td>$356,873</td>
</tr>
<tr>
<td>Annual cost of BRAC ($) – Low</td>
<td>$7,627,207</td>
</tr>
<tr>
<td>Annual cost of BRAC ($) – High</td>
<td>$90,056,177</td>
</tr>
</tbody>
</table>
# All Workers - Economic Travel Time Costs

<table>
<thead>
<tr>
<th>All Workers in BRAC-Affected PUMAs</th>
<th>DD Calculations</th>
<th>IV Calculations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data from IPUMS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avg income of all workers in BRAC-affected PUMAs ($2005)</td>
<td>$46,520.68</td>
<td>$46,520.68</td>
</tr>
<tr>
<td>Avg hrs. worked / week of all workers in BRAC-affected PUMAs (hrs)</td>
<td>40.52</td>
<td>40.52</td>
</tr>
<tr>
<td>Avg weeks worked per year of all workers in BRAC-affected PUMAs (wks)</td>
<td>47.24</td>
<td>47.24</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Calculations</strong></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Hourly income based on above ($/hr)</td>
<td>$24.30</td>
<td>$24.30</td>
</tr>
<tr>
<td>DD/DDD coefficient on interaction term (avg treatment effect) -- low</td>
<td>0.26</td>
<td>0.62</td>
</tr>
<tr>
<td>DD/DDD coefficient on interaction term (avg treatment effect) -- high</td>
<td>0.62</td>
<td>0.62</td>
</tr>
<tr>
<td>IV coefficient on endogenous variables (workers/sq km) -- low</td>
<td>0.0461</td>
<td>0.0461</td>
</tr>
<tr>
<td>IV coefficient on endogenous variables (workers/sq km) -- high</td>
<td>0.0555</td>
<td>0.0555</td>
</tr>
<tr>
<td>Total cost of BRAC for all commuters to BRAC bases ($/day) - Low</td>
<td>$656,615</td>
<td>$2,688,319</td>
</tr>
<tr>
<td>Total cost of BRAC for all commuters to BRAC bases ($/day) - High</td>
<td>$1,953,829</td>
<td>$6,478,842</td>
</tr>
<tr>
<td>Annual cost of BRAC ($) – Low</td>
<td><strong>$155,093,921</strong></td>
<td><strong>$634,987,383</strong></td>
</tr>
<tr>
<td>Annual cost of BRAC ($) – High</td>
<td><strong>$461,498,984</strong></td>
<td><strong>$1,530,317,643</strong></td>
</tr>
</tbody>
</table>
Limitations of Study

- Indirect/secondary effects within the economy not considered
- Cannot prove external validity (i.e. how are movements of troops different than an employment)
- Military sample may amplify the effect
- Unable to say definitively if travel time changes due to increase in distance or decrease in speed. However, for non-military commuters, effect should only be on speed.
- Costs are only travel time costs (many other costs associated with congestion)
- Did not account for other changes in troop levels (like deployments overseas)
Conclusions

- City planners and transportation modelers:
  - “Unplanned” rapid growth affects travel time to work, beyond trip diversion effect.
  - Adding 10 workers per square km increases travel time on average between 0.05-0.6 minutes per one-way commute.
  - Adding 10 workers per square km has an economic travel time cost of $0.18-$0.44 per day per leg of commute.
  - Public policy should always bear in mind that extreme growth has these very negative consequences.

- Department of Defense:
  - BRACs can have costly consequences for communities that gain employees.
  - More costly for civilian population than military population.
Questions?