The Effect of a Change in Employment Density on Travel Time to Work: An Empirical Analysis using Military Troop Re-Locations

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ABSTRACT

We examine how rapid and unanticipated spikes in employment affect a region's travel time to work using movements of military troops during the 2005 Base Realignment and Closure (BRAC) process. Anecdotal media reports suggest traffic congestion increased substantially due to these troop movements. The BRAC process provides a convenient quasi-experimental framework to measure this effect because it occurred exogenous to the normal transportation planning process. Using difference-in-difference, difference-in-difference-in-difference, and instrumental variable methods we estimate the effect of unanticipated employment growth for both military commuters who commute to the affected base and civilian commuters in the same region who commute to work locations offbase. We also estimate the economic travel time cost to regions when rapid employment growth occurs and find that the 2005 BRAC cost between $155 million and $1.5 billion in added travel time per year.

1. Introduction

Employment growth is a common public policy goal, but it can lead to a number of unwanted environmental, economic, and social costs in high growth communities, one of the most visible and universal of which is traffic congestion (Ladd, 1991; Freilich and White, 1991; Giuliano and Wachs, 1992). Some have shown that traffic congestion is the number one concern of citizens in rapidly growing areas in the U.S., often ranked higher than crime, school over-crowding, and housing shortages (Glickfeld & Levine, 1990; NJ, 2005; GAO, 2009). Congestion is undesirable because it discourages future economic growth (Hymel, 2009), increases vehicular emissions, increases fuel expenses, decreases economies of agglomeration, heightens the psychological burden of travel, creates a need for more emergency services, and imposes an opportunity cost on time (Downs, 1998; Down, 2004).

In 2010, the average U.S. commuter spent 34 hours in non-free flow traffic or 8.5 minutes per commute assuming a 240 day work year (Schrank et al., 2011). Employment growth is an important predictor of traffic congestion (moreso than population growth) because of its direct relationship to peak-hour traffic (Downs, 2004). Hence, transportation planners put great effort into understanding how levels and locations of employment will change in the future. However, in extreme growth communities like the city of Las Vegas in the 1990s or Atlanta in the 2000s, employment forecasts can mismatch reality[1] ultimately leading to error-prone travel demand models, inaccurate predictions of emissions, and insufficient supply of transportation services and travel demand management practices (Rodier et al., 2002).

The purpose of this paper is to estimate how rapid employment growth affects a community's travel time to work. Using two quasi-experimental methods, we estimate this relationship and the corresponding economic "costs" of the additional travel time per added worker. We also briefly discuss the opposite effect – travel time impacts in communities whose employment base is rapidly contracting. A better understanding of these relationships would help policymakers balance a healthy employment growth rate with acceptable levels of traffic. Additionally, it would assist planners evaluate acceptable tolerances of errors between the predicted and actual growth in their transportation models.

Measuring the effect of rapid employment growth on travel time is challenging because of two endogeneity problems. First, a simultaneity problem arises because an increase in congestion reduces the attractiveness of a community to potential new firms which, in turn, reduces the number of future commuters using the transportation network (Hymel, 2009). Potential new residents and business are incentivized to either locate on the outskirts of the city or in another city altogether (Downs, 1992). The second endogeneity problem stems from omitted variables (such as transportation infrastructure) that are related to both employment growth and travel time. Many congestion researchers make reference to the notion that higher growth rates are associated with worsening traffic but do not empirically estimate the relationship or deal with the endogeneity problems (Freilich and White, 1991; Downs, 2004).

To remove these two endogeneity problems we use exogenous growth shocks caused by troop re-locations by the U.S. military. In 2005, the Department of Defense (DoD) closed 29 bases and relocated 123,000 troops to 57 other bases in a process known as Base Realignment and Closure (BRAC). These 123,000 troops re-located between 2006 and 2011 and in some communities added significant numbers of commuters to the transportation networks. Since the end of the Cold War,

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[1] Typical employment forecasts used by transportation planners are in the range of +/- 2% change per year but employment spikes can reach up to 5-10% change per year.

there have been five rounds of base closures (1989, 1991, 1993, 1995, and 2005) with the primary goal of reducing the DoD physical infrastructure budget and improving the military's strategic agility. Past rounds of BRAC have closed between 17 and 33 bases and the next round is tentatively scheduled for 2015.

Figure 1 below shows the 16 bases and communities that gained the highest number of individuals through the 2005 BRAC according to the Government Accountability Office (2009) and which are used in this analysis.
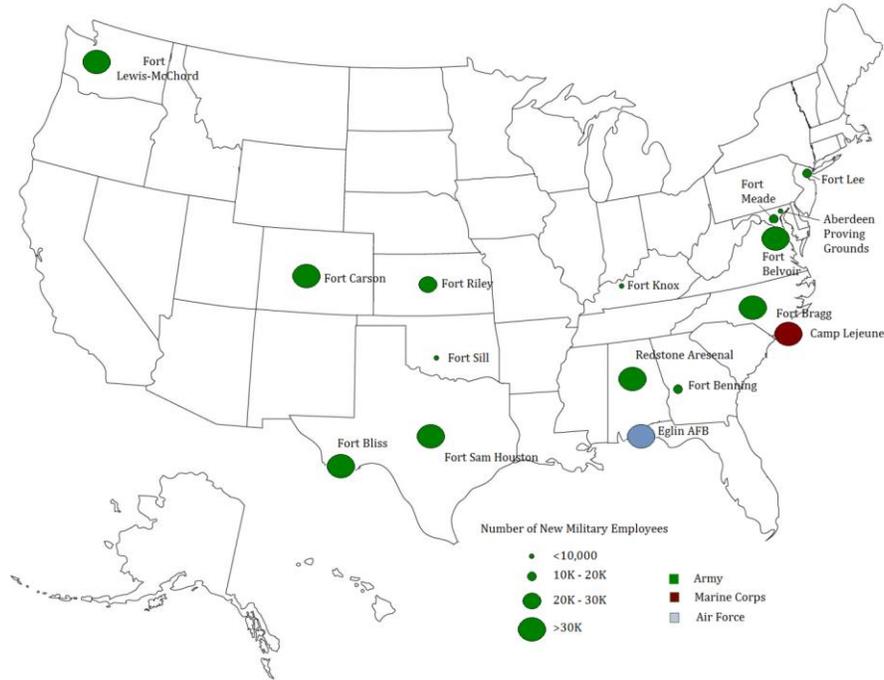

Fig 1: Domestic military bases affected in 2005 BRAC (OEA, 2012)

In this paper, we conduct two separate analyses to measure the impact of employment growth on travel time to work. In the first, we use difference-in-difference (DD) and difference-in-difference-in-difference (DDD) methods in which we compare travel time for BRAC-affected individuals to travel times for non-BRAC-affected individuals. We do this for both a military-only subgroup and a larger civilian and military group. In the second analysis, we instrument for regional employment density growth using the number of troops gained for each area (the gained range from 1,200 troops to 28,000 troops and correspond to annual growth rates in employment density (workers per square km) of 0.01-7.0%). These "gained" individuals represent the number of people who were in excess of the planned employment growth. The IV method allows us to measure a casual relationship between employment density growth and travel time. Using these two approaches, we find a robust positive impact of unanticipated employment growth on travel time.

2. Data

We use repeated cross-sectional person-level data compiled from the 2000 decennial census and the 2005-2010 American Community Surveys (ACS) and available through the University of Minnesota's IPUMS website (Ruggles et al., 2010). The years 2001-2004 were the first years of the

ACS and are omitted here because they do not include a complete set of variables. The geographic location of an individual's residence and workplace are only known within regions containing approximately 100,000 people (called PUMAs). For individuals in the military, we use a combination of their service affiliation (e.g. Air Force, Army, etc.) and their workplace region to assign them to a specific military base. We consider military individuals who are commuting from private houses or apartment buildings off-base and omit those who live onbase in barracks or on ships. Data on the number of troops gained by each community come from Table 2 of GAO (2009).

Table 1: Summary statistics of treatment and reference groups used in this analysis.

Variable	Min	Max	Military in BRAC-affected Areas Mean (std error)	US Average Mean (std error)[1]
Commute Travel Time 2000-2005	0	188	20.43 (16.16)	23.81 (23.17)
Commute Travel Time 2006-2010	0	188	22.52 (17.32)	23.58 (22.13)
Worker density (workers/sq-km)	5.66	193.3	770.2 (39.20)	2040.3 (497.40)
Age*Age	289	3721	1,037 (553.28)	1,852 (1169.63)
Education	0	16	7.61 (1.82)	7.36 (2.31)
Family members	0	1	2.90 (1.49)	2.84 (1.60)
Female	0	1	0.14 (0.35)	0.47 (0.50)
Family income ($100K)	-0.2	17.21	59,915 (39,919)	165,314 (923,530)[1]
Immigration status	0	1	0.10 (0.29)	0.17 (0.37)
Num. riders in car	0	9	1.08 (0.52)	0.99 (0.70)
Hours worked	0	99	53.23 (14.50)	39.46 (12.50)
Vehicles per family member	0	6	1.15 (0.61)	1.20 (0.72)
Married	0	1	0.71 (0.45)	0.53 (0.50)
Population density (people/sq-km)	11.2	340.8	86.70 (70.90)	402.60 (842.10)
Lives in rural area	0.0	1	0.16 (0.36)	0.15 (0.36)
Lives in urban area	0	1	0.13 (0.34)	0.15 (0.36)
Train density (train operators/sq-km)	0	0.36	0.015 (0.043)	0.32 (1.55)
Bus density (bus operators/sq-km)	0.0	0.67	0.047 (0.090)	0.91 (3.62)
Sample Size unweighted (weighted)			**6,093 (631,802)**	**9.60E6 (9.81E8)**

[1] All employed people between 17-61 years old.

[2] Family income should not be confused with per capita income which is much lower for the US. Family income refers to all pre-taxed income by one's family and is likely skewed upwards by high income individuals.

Table 1 shows summary statistics of the military BRAC population and the US general population for all variables used in our analysis. For brevity, we do not show summary statistics for all subgroups considered in our DD(D) and IV. However, these summary statistics are available in table A-1 of the Appendix.

3. Treatment of Endogeneity

The 2005 BRAC troop movements address the endogeneity problems between employment growth and travel time because the growth occurs as a result of an exogenous top-down governmental mandate, not as part of a normal employer location decision. In other words, the government does not adjust the number of troops it sends to an area because of increasing levels of congestion. Rather the relationship is unidirectional – congestion increases as more troops move into an area. Certainly, there could be indirect effects from non-military firms. As the level of troops and congestion increase in a BRAC-affected region, civilian organizations may be less likely to move

into an area. However, as discussed below, the 2005 BRAC occurred so suddenly that other firms would have little opportunity to react to increased congestion levels. If firms did indeed choose not locate in BRAC-affected areas because of increased congestion, then our results would underestimate the effect of employment growth on travel time to work and a significant effect would be more difficult to detect.

To demonstrate that the 2005 BRAC troop re-locations were unrelated to the level of infrastructure expansion, a longer discussion about the nature and timing of the BRAC process is needed. A National Academies of Science (2011) report states: "The problems for state and local jurisdictions in BRAC cases are attributable to the rapid pace of traffic growth on heavily used facilities….The normal length of time for development of highway and transit projects – from required planning and environmental processes all the way through construction – is, at best, nine years and usually 15 to 20 years" (p. 7, NAS, 2011).

Re-locations of troops in the 2005 BRAC were to begin in January 2006 and finish by September, 2011. As shown in Table 2, not until the spring of 2005 did the Department of Defense submit a list of bases they recommended for closing. Even if a base was on a list, however, did not mean it was guaranteed to be closed. Media reports from that summer indicate real estate investors were hesitant to make definitive plans until the final recommendations were made in September 2005 (Hedgepeth, 2005). Action by transportation planners would not have begun until November, 2005 when the President approved the final list of base realignments. Thus, planners had a minimum of three months to begin planning for the first troop movements.

Table 2: Timeline of 2005 BRAC Process

Date	Action
Dec. 28, 2001	Congress authorizes DoD to explore options for a 2005 BRAC
Mar. 23 , 2004	DoD provides troop inventories of all bases to congress
Apr. 1, 2005	Congress appoints 8-member BRAC commission to oversee BRAC process
May 16, 2005	Secretary of Defense submits recommendations of base closures to BRAC commission
Sept. 8, 2005	BRAC commission provides recommendations for realignments to congress
Nov. 7, 2005	President approves BRAC base realignment list
Jan. 1, 2006	Troop relocations begin
Sept. 30, 2011	Deadline for completion of troop movements

The Washington DC area – a region with numerous BRAC-affected bases – provides an example of the duration of infrastructure improvements. Closely following the final list of base realignments, the Washington DC Metropolitan Planning Organization announced plans to expand I-375 to help facilitate the additional troops at Fort Meade, Maryland. By the deadline for completion of the BRAC process in September, 2011, the additional lanes of highway still had not been added (Washington Post, 2011). Furthermore, in 2011 in response to public criticism towards the BRAC-related traffic congestion, the head of the Washington DC Metropolitan Planning Organization exclaimed "We just don't have the resources to add capacity when they [US Congress] just drop these things [BRAC] out of the sky," (Ron Kirby, 2011).

Typically, detailed traffic studies are needed to justify any major transportation infrastructure expansion. These studies are followed by a planning and design phase and then by public discussion. Finally, permitting and construction often takes more than a year unless public safety is a concern. Infrastructure capacity expansion projects are listed on the Metropolitan Planning Organization's Long-Range Transportation Plan which has a planning horizon of 20 years.

The second piece of evidence that demonstrates the exogeneity of the BRAC process to the level of infrastructure expansion is the important role of city-level finances. NAS (2011) describe how little financial support from the federal government was given to BRAC-affected communities. A majority of community developments nowadays require an impact fee or levy to be paid by the developer to compensate the community for additional transportation services (and other services) which will result from the new development. However, because troop movements as part of the 2005 BRAC were not part of a normal development, cities did not receive financial assistance for increased infrastructure beyond a single program known as the Defense Access Roads. NAS (2011) finds that:

> "The Defense Access Roads (DAR) program is inadequate for base expansion in built-up areas. Eligibility is determined by the criterion of a doubling of traffic, which is impossible on already congested facilities. Aside from DAR, DoD policy states that local and state authorities are responsible for off-base transportation facilities even if DoD decisions increase congestion; this policy is unrealistic for congested metropolitan transportation networks. Moreover, off-base projects compete poorly in the military construction (MILCON) budget, which also funds the higher priorities of base commanders for on-base facilities. Finally, DAR is limited to road projects, whereas transit is often necessary to serve some travel demand in congested metropolitan areas" (p. 2).

Using the US military to measure the relationship between employment growth shocks and travel time has a number of benefits. First, the Department of Defense maintains well-kept records on troop levels at its bases allowing us to know exactly how many employees commutes to each base in each year. Also, the U.S. military is relatively homogenous between bases in its demographic composition meaning BRAC-affected bases gain or lose similar distributions of personnel between bases. Military bases exist in a geographically diverse set of cities and towns allowing us to examine the effect of employment growth shocks on different parts of the country. Lastly, military bases were selected for BRAC based on budgetary savings potential rather than in a systematic way that could bias the travel times.

There are also disadvantages to using a population of military for this analysis. First, a number of important differences exist between commuting to a military base and commuting to an average workplace. According to 2000-2010 census data, military bases reach peak traffic at 7:45 in the morning and 4:32 in the afternoon while the civilian traffic is at 8:32am and 5:47pm (Ruggles et al., 2012). Therefore, military members commute at slightly off-peak times which would likely lessen a change in travel time due to BRAC. Military commuters also have fewer alternatives to driving than civilians because of lack of public transit, no option to telecommute, and often low density built environment on base[2]. Military also generally have a greater preference for driving to work than their civilian counterparts -- 94% of military commute by auto while 89% of civilians commute by auto (Ruggles et al., 2012). A higher drive-to-work rate could have an amplification effect on traffic congestion in the face of employment growth. Also, military commuters must pass through security gates on their way to work. The impact of these gates is not quantified here but, as is known by all drivers, bottlenecks amplify the effect of traffic congestion (FHWA, 2004).

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[2] We collected data on 85 domestic military bases from DoD (2011) and found that military bases have a range of different land use and transit availability.

4. Difference-in-Difference and Difference-in-Difference-in-Difference Estimation

4.1 Military Commuters in BRAC regions

We use both difference-in-difference (DD) and difference-in-difference-in-difference (DDD) linear regression models with geographic and year fixed effects and a vector of control variables to explore the relationship between employment growth shocks and change in travel time. DD(D) estimations measure the impact of an intervention or policy by comparing the treated group with one (or two in the case of DDD) comparison group(s) both before the policy and after the policy. The difference in trends between the comparison and treated groups is attributed to the effect of the intervention. Here, we are comparing travel times of individuals in BRAC-affected regions with travel times in non-BRAC-affected regions.

In an ideal DD(D) experiment, the BRAC and non-BRAC communities would be identical in every way except the introduction of the BRAC in one community. Since such an experiment would be prohibitively expensive at large-scale, the key to a successful DD(D) is choosing comparison groups as similar as possible to the treatment. Here we estimate six different DD(D) models described below.
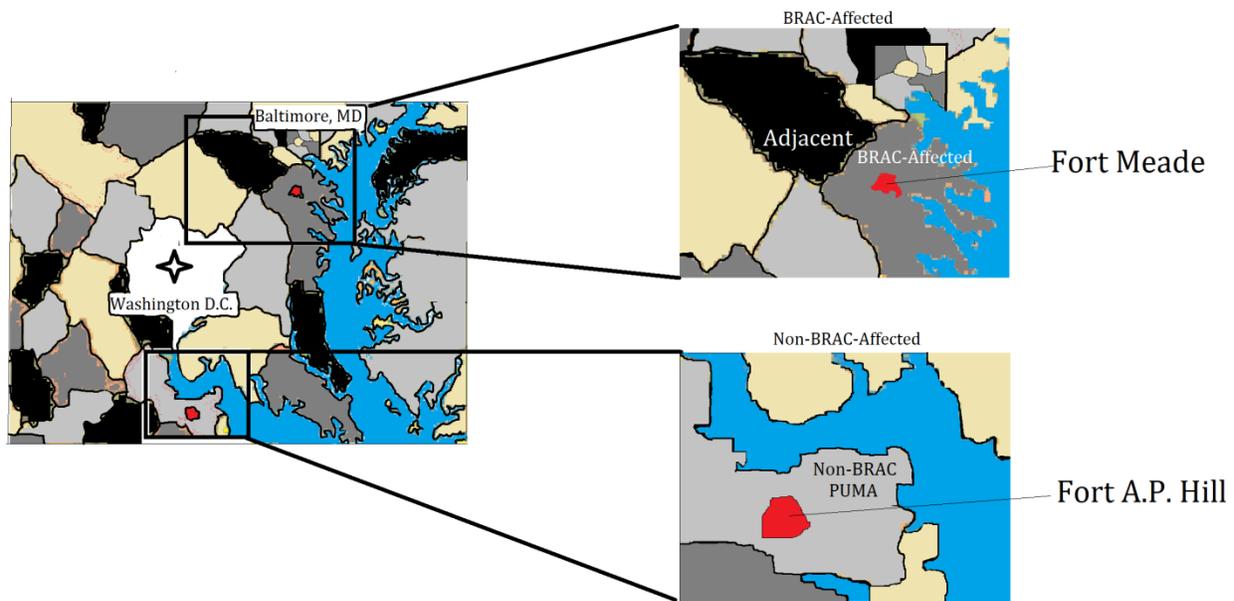
Fig. 2: Examples of treatment and comparison groups in DD(D) models near Washington D.C. Military bases shown in red. Fort Meade gained 28,000 new workers as a result of the 2005 BRAC. Fort A.P. Hill neither gained nor lost workers in the BRAC.

In our first DD model (DD-1), we compare the travel time to work of military personnel in the BRAC communities with civilians in the BRAC communities. Using Figure 2 as an example, DD-1 would compare the military members who commute to the BRAC-affected Fort Meade (and the 15 other BRAC-affected bases) with civilians who work in the same BRAC-affected PUMA as Fort Meade (dark grey region surrounding Fort Meade). A dummy variable is used to distinguish between the pre-BRAC period (2000 and 2005) and post-BRAC period (2006-2010). The advantage of the reference group in DD-1 is that, by sharing the same geographic area with BRAC-affected

individuals, the two groups have similar land-use compositions and transportation infrastructure. However, the disadvantage of this comparison group is that these civilians are also affected by increased traffic congestion caused by the troop re-locations since they work in the vicinity of a BRAC-affected base. If this is true, however, it would mean a significant effect would be more difficult to detect. The second disadvantage is that, as civilians, this reference group may not be exposed to policies, traffic regulations, or infrastructure specific to military bases.

To help control for these influences we include the DD-2 model which uses a reference group of military individuals on *non-BRAC affected bases*. Again, using Figure 2 as an example, DD-2 would compare military travel time of workers on Fort Meade (and 15 other treatment bases) with military workers at Fort AP Hill (37 non-BRAC-affected bases total). The advantage of this reference group is that it controls for military-specific factors that affected commute travel in the years 2000-2010. The disadvantage of this reference group is that these individuals may be influenced by different set of city-level factors such as land-use, weather, transit availability, etc since these bases are located in other regions of the country.

Since both DD-1 and DD-2 have advantages and disadvantages, we estimate a third model (DDD-1) which uses the reference groups from both models. DDD-1 gives the effect of employment growth on travel time with respect to both a reference group in the same geographic area and a non-affected military group.

4.2 All Commuters in BRAC Regions

We are also interested in the effect on travel time for *all* commuters in BRAC-affected PUMAs (civilians and military). In DD-3 we compare military and civilian commuters in BRAC-affected regions with military and civilian commuters in adjacent PUMAs (in Figure 2, this group works in the "adjacent" PUMA). Like DD-1, the hope with DD-3 is that by choosing reference groups that are geographically close, we mostly control for built environment variables. However, there are certainly a number of important variables that might affect one group but not the other. DD-4 uses a similar comparison group as DD-2 (the non-BRAC-affected PUMAs) but counts all civilians rather than just the military commuters (in Figure 2, this group is in the "non-BRAC PUMA").

Thus, we also attempt DDD-2 model in which we compare military and civilian commuters in BRAC-regions to military and civilians in adjacent PUMAs and military and civilians in non-BRAC-affected PUMAs with military bases. Table 3 below summarizes the three models.

Table 3: Descriptions of DD(D) models

Model	Population of Interest	Description of Model
DD-1	Military only	Treatment works at BRAC-affected bases and is military. Comparison group works in same geographic region (i.e. PUMA) as BRAC-affected base but does not work onbase and are civilians.
DD-2	Military only	Treatment group works at BRAC-affected bases. Comparison group works at unaffected bases and are military members.
DDD-1	Military only	Treated individuals work at BRAC-affected bases. Two comparison groups are used (same as DD-1 and DD-2).
DD-3	Civilians + Military	Treatment groups works in BRAC-affected PUMAs. Reference group works at non-BRAC-affected PUMAs that have military bases.

| DD-4 | Civilians + Military | Treatment groups works in BRAC-affected PUMAs. Reference group works at non-BRAC-affected PUMAs that have military bases. |
| DDD-2 | Civilians + Military | Treatment groups works in BRAC-affected PUMAs. Reference groups work 1) at non-BRAC-affected PUMAs that have military bases or 2) in adjacent PUMAs. |

Equation 1 is used to estimate the DD-1, DD-2, DD-3, and DD-4 models.

$$TT_{irt} = \alpha + \beta_1 post_t + \beta_2 treated_{irt} + \delta post * treated_{irt} + \varphi_r + \theta_t + X_{irt}'\gamma + \varepsilon_{irt} \qquad (1)$$

where TT_{irt} is travel time of individual i, in PUMA r, in year t; a is a constant, $post_t$ is a dummy variable indicating after the year 2005, $treated_{irt}$ is a dummy variable for an active duty military member in DD-1 and DD-2 and for a military or civilian worker in a BRAC-affected PUMA for DD-3 and DD-4, $post * treated_{irt}$ is an interaction variable indicating an individual is in the treated group and in the post period, φ_r are state fixed effects, θ_t are year fixed effects, and X is a vector of control variables. The coefficient of interest is δ, the coefficient on the $post * treated_{irt}$ interaction, as it is our difference-in-difference estimator.

Equation 2 is used to estimate DDD-1.

$$TT_{irt} = \alpha + \beta_1 post_t + \beta_2 military_{irt} + \beta_3 post * military_{irt} + \beta_4 post * BRAC_{Affected\,irt} \qquad (2)$$
$$+ \beta_5 military * BRAC_{Affected\,irt} + \delta post * military * BRAC_{Affected\,irt}$$
$$+ \varphi_r + \theta_t + X_{irt}'\gamma + \varepsilon_{irt}$$

Where $military_{irt}$ are military personnel, $post_t*military_{irt}$ are military personnel after 2005, $post*BRAC$-$affected_{irt}$ are military or civilians who live in a BRAC-affected region after 2005, $military_*BRAC$-$affected_{irt}$ are military personnel in BRAC-affected regions, $post*military*BRAC$-$affected_{irt}$ is the interaction term of interest for military personnel who live in the BRAC-affected regions in years after 2005, and other terms are those defined above.

The specification for the DDD-2 model is similar to DDD-1. Using Equation 2, the term "military" refers to all employees in a PUMA with a military base (both BRAC-affected and non-BRAC-affected bases), and the $BRAC$-$affected_{irt}$ term refers to all employed individuals who work in a BRAC-affected PUMA or in a PUMA directly adjacent to a BRAC-affected PUMA. Thus, in DDD-2, the coefficient δ on the triple interaction term, $post*military_{irt}*BRAC$-$affected_{irtr}$ gives the effect of the BRAC on travel time in relation to adjacent PUMAs and other PUMAs with non-BRAC-affected military bases.

Table 4 provides summary statistics of travel time and worker density for the six DD(D) models. Other variables means and standard errors are shown in table A-1 in the Appendix.

Table 4: Partial summary statistics for DD(D) models for travel time and worker density. Other variables' statistics available in Appendix.

Variable	Obs.	Weighted Obs	Mean	Std. Dev	Min	Max

DD1 - Treatment (Military on BRAC-affected Bases)

Commute Travel Time 2000-05 (min.)	1,596	158,371	20.43	16.16	0	183
Commute Travel Time 2006-10 (min.)	4,497	473,431	22.52	17.32	0	188
WP Worker Density (workers/sq. km)	6,093	631,802	766.12	1614.43	0.27	24381.79

DD1 - Comparison (Civilians in BRAC-affected PUMAs)

Commute Travel Time 2000-05 (min.)	49,241	5,075,661	24.99	21.95	0	196
Commute Travel Time 2006-10 (min.)	134,651	14,060,517	25.28	21.45	0	200
WP Worker Density (workers/sq. km)	183,892	19,136,178	2532.49	3534.46	0.32	194504.9

DD2 - Treatment (Military on BRAC-affected bases)

Same as DD1 - Treatment

DD2 - Comparison (Military in Non-BRAC-Affected PUMAs)

Commute Travel Time 2000-05 (min.)	1,546	155,681	23.5	24.67	0	185
Commute Travel Time 2006-10 (min.)	4,060	424,647	22.11	20.66	0	195
WP Worker Density (workers/sq. km)	7,202	738,699	1855.92	6995.61	0.34	163266.1

DD3 - Treatment (All employed individuals in BRAC-affected PUMAs)

Commute Travel Time 2000-05 (min.)	50,837	5,234,032	24.86	21.81	0	196
Commute Travel Time 2006-10 (min.)	139,148	14,533,948	25.19	21.34	0	200
WP Worker Density (workers/sq. km)	189,985	19,767,980	2476.03	3503.28	0.27	194504.9

DD3 - Comparison (All employed individuals in adjacent PUMAs)

Commute Travel Time 2000-05 (min.)	33,798	3,414,238	25.32	23.34	0	197
Commute Travel Time 2006-10 (min.)	89,601	9,191,007	25.25	22.43	0	200
WP Worker Density (workers/sq. km)	123,398	12,605,058	2790.01	4438.69	0.64	87211.6

DD4 - Treatment (All employed individuals in BRAC-affected PUMAs)

Same as DD3 Treatment

DD4 - Comparison (All employed individuals non-BRAC-affected PUMAs with Military Bases)

Commute Travel Time 2000-05 (min.)	135,665	14,112,097	26.4	23.53	0	200
Commute Travel Time 2006-10 (min.)	366,093	39,686,549	25.83	22.03	0	200
WP Worker Density (workers/sq. km)	501,757	53,798,592	13758.7	24825.33	0.068	545081.7

DDD1 - Treatment (Military in BRAC-affected PUMAs)

Same as DD1 - Treatment

DDD1 - Comparison #1 (Civilians in BRAC-affected PUMAs)

Same as DD1 Comparison

DDD1 - Comparison #2 (Military in Non-BRAC-Affected PUMAs)

Same as DD2 Comparison

DDD2 - Treatment (Civilians and Military in BRAC-affected PUMAs)

Same as DD1 - Treatment

DDD2 - Comparison #1 (Civilians and Military in BRAC-affected PUMAs)

Same as DD3 Comparison

DDD2 - Comparison #2 (Civilians and Military in non-BRAC-affected PUMAs with Military Bases)
   Same as DD4 Comparison

Table 5 shows the results for the five DD(D) models, each with two specifications. For brevity, the control variables are not shown in the main text but are given in the appendix. The interaction term is positive and significant across specifications. Results of the DD(D) estimator δ show that the employment growth of the 2005 BRAC is associated with 0.26 to 4.89 minutes of additional travel time per commute trip.

Table 5. Interaction terms in DD(D) models for Drivers only and Full models.

	Military Only Models						Civilians & Military Models					
	DD-1		DD-2		DDD-1		DD-3		DD-4		DDD-2	
VARIABLES	Drivers Only	Full Model	Drivers Only	Full Model	Drivers Only	Full Model	Drivers Only	Full Model	Drivers Only	Full Model	Drivers Only	Full Model
Interaction Effect	0.630***	0.829***	4.076***	4.894***	0.867***	0.921***	0.617***	0.615***	3.076***	2.894***	0.263***	0.411***
Std. Error	(0.0738)	(0.0736)	(0.0976)	(0.103)	(0.0868)	(0.088)	(0.0291)	(0.0287)	(0.0576)	(0.203)	(0.0367)	(0.0367)
Control Variables‡	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs. (millions)	3.9	4.2	0.63	0.67	12.3	13.6	9.3	9.9	0.63	0.67	26.7	29.2
R-squared	0.589	0.566	0.636	0.599	0.56	0.539	0.567	0.541	0.636	0.599	0.544	0.513

Standard errors in parentheses
*** $p<0.001$

‡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

5. Instrumental Variable Estimation

Our second approach to estimating the effect of employment growth on travel time to work uses the number of gained individuals in the 2005 BRAC as an instrument for employment growth. The requirements of an instrumental variable are that it must be related to the endogenous variable but unrelated to the dependent variable except through the endogenous variable. This exogeneity was discussed in Section 2. It should be noted that normal (non-military related) employment growth is occurring at the same time as the BRAC troop re-locations. However, the coefficient on the endogenous variable, worker density, is measuring the impact of only the density changes due to BRAC. Table 6 gives summary statistics of the travel time and worker density of each of the subgroups analyzed. Summary statistics of other variables are shown in table A-1 of the Appendix.

Table 6: Summary statistics for travel time and worker density for four IV models. Other summary statistics available in the Appendix.

Variable	Obs.	Weighted Obs.	Mean	Std. Dev	Min	Max
IV - 1 (Civilians and Military in BRAC-affected PUMAs who report driving to work)						
Commute Travel Time (min.)	146,953	15,375,148	24.5	21.28	0	200
WP Worker Density (workers/sq. km)	146,953	15,375,148	26295.61	17062.55	1600	69700
IV - 2 (Civilians and Military in BRAC-affected PUMAs who report driving to work)						
Commute Travel Time (min.)	132,778	13,773,195	25.66	20.19	1	195
WP Worker Density (workers/sq. km)	132,778	13,773,195	2456.52	3545.45	0	194505
IV - 3 (Military in BRAC-affected PUMAs)						
Commute Travel Time (min.)	4,497	473,431	22.52	17.32	0	188
WP Worker Density (workers/sq. km)	4,497	473,431	26172.1	16281.4	1600	69700
IV - 4 (Military drivers in BRAC-affected Bases)						
Commute Travel Time (min.)	4,286	450,945	22.58	16.41	1	185
WP Worker Density (workers/sq. km)	4,286	450,945	26142.13	16109.33	1600	69700

Like the DD(D) models, we run specifications with military and military + civilian subgroups. The IV model specification is:

$$TT_{irt} = a + \beta_1 WD_{rt} + \beta_2 TT_{t-1,r} + \beta_3 IX_{irt} + \varphi_r + \theta_t + X_{irt}'\gamma + \varepsilon_{irt} \qquad (3)$$

Where TT_{irt} is travel time to work for individual i, in PUMA r, in time t, WD_{rt} is the worker density of PUMA r, in time t; $TT_{t-1,r}$ is the average travel time to work in region r in period t-1. This variable acts similar to a PUMA-level fixed effect and accounts for variation in travel times between regions. IX_{irt} are interaction terms between the worker density variable and income, age, gender, education, and number of household vehicles per adult household member. These interaction terms only appear in our "interaction model." φ_r are state-level fixed effects, θ_t are year fixed effects, $X_{irt}'\gamma$ are the same vector of control variables as in the DD(D) models, and ε_{irt} is the disturbance term.

Results of eight IV models are shown in Table 5 below. Only the coefficients on worker density and on the interactions between worker density and household characteristics are shown. Full results are shown in the Appendix. For models with interaction terms, the interaction terms are evaluated at the mean value of the household characteristics in each respective interaction.

As shown in Table 5, the signs of the endogenous variable for the "Full Models" and the average effect for the interaction models are similar in magnitude, although the average effect is slightly lower in all eight models. It should be noted that the magnitude of the military-only models are smaller across all model specifications. We do not yet have a good explanation for why this occurs.

Table 7: Results of eight IV models. The average effect for interaction terms is estimated using the mean value of the respective interacted variable (e.g. age). First stage regressions and coefficients of control variables are shown in Appendix 1.

VARIABLES	Military Only Models				Civilians + Military Models			
	All Commuters		Drivers Only		All Commuters		Drivers Only	
	No IX	Interaction	No IX	Interaction	No IX	Interaction	No IX	Interaction
Average Effect	0.00698****	0.0053****	0.00594****	0.00324****	0.0555****	0.05133****	0.0494****	0.0461****
Std. Error	(0.0005)	(0.1030)	(0.0004)	(0.0291)	(0.0004)	(0.0738)	(0.0004)	(0.1050)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-Stat	89.37	1387.29	63.85	799.20	10617.36	4959.60	7575.42	89.37
Observations	278036.00	278036	265161	265161	3129734	3129734	2935207	2935207
R-squared	0.59	0.57	0.64	0.60	0.57	0.54	0.54	0.51

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

[‡]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

6. Relationship with Built Environment Literature

For the past two decades urban planners have sought to understand if and how changing urban form can reduce energy use, emissions, and the vehicle miles travelled of personal vehicles. Conclusions on this topic vary widely. A NAS (2009) report reviewed several key papers and found that the effect of land use strategies to change travel behavior is likely moderate in the short term and potentially more significant in the long-term. Much of the research has explored relationships between densities (e.g. employment, population, transit, parking) and travel behavior. According to Cervero (2002) density variables act as proxies for other difficult-to-measure variables such as jobs-housing balance, land form, mixed land use, and transit oriented development. While our study also looks at the role of density on travel behavior, we do not manipulate the urban form when changing densities through BRAC. Thus, the fact that density in BRAC-affected areas increases due to BRAC is not, in itself, a measure of a changing urban form.

7. Economic Costs of Travel Time

Spending additional minutes traveling to work implies an economic opportunity cost. Many suggest that the specific level of service matters when quantifying travel time costs: waiting an additional hour in congested traffic is more costly than waiting an hour in freeflow traffic (Wardman, 1986; Fosgerau et al., 2007). Wardman et al. (2012) use a state choice survey and find that individuals value congested traffic in the UK from 1.18-1.80 times more costly (from light congestion to heavy congestion) compared to freeflow traffic. Others find that the specific mode matters: an hour in a car is less costly than an hour in a crowded bus (Abrantes and Wardman, 2011). Zamparini and Reggiani (2007) conduct a meta-analysis of 90 studies that measure the value of travel time for individuals driving cars. They report that, on average, studies find that travelers value an hour stuck in traffic at 0.82 times their wage rate. Littman (2010) conducts a similar meta-analysis and suggests that when quantifying travel time costs a range of 0.5-1.0 times the individual's wage rate should be used.

Here, we follow Littman and give a large range of potential travel time costs. From 2006-2010 the average income of military individuals at the BRAC-affected bases was $46,455 per year ($2005) or $17.29/hour using the average number of hours worked per year of 2,686 hrs (Ruggles et al., 2012). Thus, we approximate that each additional man-hour stuck in traffic congestion results in a cost of $8.65-$17.29 per military commuter. Using the range of coefficients estimated in the DD(D) and IV models, the total cost of the 2005 BRAC to all military commuters is between $1.09-$90.1 million per year ($2005). Applying the same calculations to the non-military workers average wage rate of $24.30 per hour, we find the total cost of the 2005 BRAC due to increased commuting time was $155.1-$1,530.3 million per year ($2005). Results are summarized in Tables 8 and 9 below. The left-hand column uses highest and lowest coefficients of the DD(D) models while the right-hand column uses the highest and lowest coefficients of the IV models. Bolded cells at the bottom provide the range of estimates for each method using 0.5 and 1.0 for wage rate multipliers.

Table 8: Calculations of travel time costs for military members at BRAC-affected bases

Military Members	DD Calculations	IV Calculations
Data from IPUMS		
Avg income of military in BRAC-affected PUMAs ($2005)	$46,455	$46,455
Avg hrs. worked / week by military in BRAC-affected PUMAs (hrs)	53.23	53.23
Avg weeks worked per year by military in BRAC-affected PUMAs (wks)	50.47	50.47

	2686.63	2686.63
Calculations		
Hourly Income based on above ($/hr)	$17.29	$17.29
DD/DDD coefficient on interaction term (avg effect) --low	0.63	
DD/DDD coefficient on interaction term (avg treatment effect) -- high	4.90	
IV coefficient on endogenous variables (workers/sq km) -- low		0.0032
IV coefficient on endogenous variables (workers/sq km) -- high		0.0051
Total cost of BRAC for all military commuters to BRAC bases ($/day) – Low	$30,225	$4,301
Total cost of BRAC for all military commuters to BRAC bases ($/day) - High	$356,873	$294,637
Annual cost of BRAC ($) – Low	**$7,627,207**	**$1,085,303**
Annual cost of BRAC ($) – High	**$90,056,177**	**$74,351,219**

Table 9: Calculations of travel time costs for civilians and military members working in BRAC-affected PUMAs

All Workers in BRAC-Affected PUMAs	DD Calculations	IV Calculations
Data from IPUMS		
Avg income of all workers in BRAC-affected PUMAs ($2005)	$46,520.68	$46,520.68
Avg hrs. worked / week of all workers in BRAC-affected PUMAs (hrs)	40.52	40.52
Avg weeks worked per year of all workers in BRAC-affected PUMAs (wks)	47.24	47.24
Calculations		
Hourly income based on above ($/hr)	$24.30	$24.30
DD/DDD coefficient on interaction term (avg treatment effect) --low	0.26	
DD/DDD coefficient on interaction term (avg treatment effect) -- high	0.62	
IV coefficient on endogenous variables (workers/sq km) -- low		0.0461
IV coefficient on endogenous variables (workers/sq km) -- high		0.0555
Total cost of BRAC for all commuters to BRAC bases ($/day) - Low	$656,615	$2,688,319
Total cost of BRAC for all commuters to BRAC bases ($/day) - High	$1,953,829	$6,478,842
Annual cost of BRAC ($) – Low	**$155,093,921**	**$634,987,383**
Annual cost of BRAC ($) – High	**$461,498,984**	**$1,530,317,643**

We conduct similar calculations for all commuters in BRAC-affected regions and for the US general employed population using the IV coefficients and the estimated US-wide wage rate in Table 8. Use of DD(D) coefficients is not possible for the US-wide effect. We estimate a cost of $0.18-0.44 per commuter when one additional employee is added per sq km. While the IV method is often regarded as the "gold standard" in terms of casual models, it says nothing about whether results are externally valid. Thus, these US-wide estimates should be viewed with some degree of caution.

It should be noted that Downs (2004) expresses concern about simple travel time value calculations based on wage rate because no two people experience the same cost and some even report a net benefit from added travel time. However, for our purposes such a calculation provides a convenient quantification of the burden imposed by the BRAC and allows for comparison with other costs and benefits. For example, while our estimates for the total cost of the 2005 BRAC BRAC due to increased commuting time was $155.1-$1,530.3 million per year ($2005), the DoD

estimated that the 2005 BRAC would provide $37 billion in savings over ten years. A full costing of BRAC, however, would include the cost of added travel time as well as other economic costs and benefits associated with the BRAC employment growth.

Table 10: Average cost of employment growth for all of US workers

Average Effect of Employment Growth	IV Calculations
Data from IPUMS	
Avg income of all US workers ($2005)	$44,855.77
Avg hrs. worked / week (hrs/wk)	39.94
Avg weeks worked per year (wks)	46.82
Calculations	
Hourly income based on above ($/hr)	$23.99
IV coefficient on endogenous variables (workers/sq km) -- low	0.0461
IV coefficient on endogenous variables (workers/sq km) -- high	0.0555
Cost of 10 additional people per sq km ($/commuter/day) -- low	**$0.18**
Cost of 10 additional people per sq km ($/commuter/day) -- high	**$0.44**

8. Conclusions

When policymakers craft legislation for job growth, they should work with transportation planners to realize synergistic benefits in traffic flow and job growth. To some extent, transportation networks are self-regulating (Littman, 2010) and added travelers will eventually find alternative routes, departure times, or modes to partially compensate for congested roadways. While past research has shown that the total employment size of an area is positively correlated with travel time to work, no research has shown that the rate of increase matters. Our analysis suggests that, absent infrastructure expansion, rapid increases in the number of commuters increases travel time to worker by a 0.0032-0.055 additional minutes of travel per commuter for each additional commuter added to the network per sq. km.

We also estimate the economic travel time cost of the 2005 BRAC to military and civilian employees as between $155 and $1.5 billion per year. We suggest that a full accounting of the economic costs of BRAC be included in future BRAC processes which include travel time costs as well as other costs and benefits not measured here. Lastly, we estimate the effect of unanticipated employment growth on the average US commuter and find that an additional commuter per square km will cost $0.18-0.44 per day per commuter.

Freight transportation is also affected by increased congestion levels because delays in shipping will inevitably create economic burdens for freight firms, particularly those with perishable products. Due to lack of the necessary freight transport data, we do not attempt to measure this cost here.

A couple specific caveats should be mentioned regarding the data and the conclusions. Considerable heterogeneity exists between cities in their spatial structure, transit availability, transportation policy, natural barriers to travel, and demographic composition. The findings in this study are "average effects." If we were to take similar measurements on the city-level or neighborhood level, the results could differ. Also, readers should be reminded that employment density is simply the number of employed workers per square km, by PUMA. This measure does not

capture where the commute trips originate or terminate (except for the fact they terminate on military bases) and thus we do not know whether changes in travel time are the result of slower traffic or greater trip lengths.

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APPENDIX

Table A-1: Summary statistics for DD1 groups

DD1 - Treatment (Military on BRAC-affected Bases)						
Variable	**Obs.**	**Weighted Obs.**	**Mean**	**Std. Dev**	**Min**	**Max**
Commute Travel Time 2000-05 (min.)	1,596	158,371	20.43	16.16	0	183
Commute Travel Time 2006-10 (min.)	4,497	473,431	22.52	17.32	0	188
WP Worker Density (workers/sq. km)	6,093	631,802	766.12	1614.43	0.26672	24381.7
Age (yrs)	6,093	631802	31.18	8.05	17	61
Age Squared (yrs^2)	6,093	631802	1037.1	553.28	289	3721
Family Inc. ($10,000)	6,093	631802	59.92	39.92	0	730.5
Education (yrs)	6,093	631,802	7.61	1.82	0	11
Female (0,1)	6,093	631,802	0.14	0.35	0	1
Veh. Per Adult in Household (No.)	6,093	631,802	1.15	0.61	0	6
Family Size (No.)	6,093	631,802	2.9	1.49	1	11
Married (0,1)	6,093	631,802	0.71	0.45	0	1
Immigrated to U.S. (0,1)	6,093	631,802	0.1	0.29	0	1
Hrs. worked per Wk (hrs.)	6,093	631,802	53.23	14.5	0	99
Kids in Household (No.)	6,093	631,802	1.05	1.19	0	8
Bus Density (bus workers/sq km.)	6,093	631,802	0.76	2.64	0	156.47
Train Density (train workers/sq km.)	6,093	631,802	0.25	0.8	0	22.05
Urban Household (0,1)	6,093	631,802	0.13	0.34	0	1
Rural Household (0,1)	6,093	631,802	0.15	0.36	0	1
WP Bus Density (bus workers/sq. km)	3,760	381,345	0.2	0.65	0	33.42
WP Train Density (train wkrs/sq. km)	3,760	381,345	0.07	0.44	0	16.52
DD1 - Comparison (Civilians in BRAC-affected PUMAs)						
Commute Travel Time 2000-05 (min.)	49,241	5,075,661	24.99	21.95	0	196
Commute Travel Time 2006-10 (min.)	134,651	14,060,517	25.28	21.45	0	200
WP Worker Density (workers/sq. km)	183,892	19,136,178	2532.49	3534.46	0.32	194504.9
Age (yrs)	183,892	19,136,178	39.24	11.81	17	61
Age Squared (yrs^2)	183,892	19,136,178	1679.35	931.51	289	3721
Family Inc. ($10,000)	183,892	19,136,178	82.77	73.98	-19.99	1721
Education (yrs)	183,892	19,136,178	7.46	2.31	0	11
Female (0,1)	183,892	19,136,178	0.47	0.5	0	1
Veh. Per Adult in Household (No.)	183,892	19,136,178	1.23	0.71	0	6
Family Size (No.)	183,892	19,136,178	2.95	1.6	1	16
Married (0,1)	183,892	19,136,178	0.54	0.5	0	1
Immigrated to U.S. (0,1)	183,892	19,136,178	0.18	0.39	0	1
Hrs. worked per Wk (hrs.)	183,892	19,136,178	40.52	11.43	1	99
Kids in Household (No.)	183,892	19,136,178	0.87	1.13	0	9
Bus Density (bus workers/sq km.)	183,892	19,136,178	1.55	3.12	0	274.9268
Train Density (train workers/sq km.)	183,892	19,136,178	0.55	1.09	0	67.98153
Urban Household (0,1)	183,892	19,136,178	0.23	0.42	0	1
Rural Household (0,1)	183,892	19,136,178	0.06	0.25	0	1
WP Bus Density (bus workers/sq. km)	39,941	3,851,335	0.11	0.39	0	30.96419
WP Train Density (train wkrs/sq. km)	39,941	3,851,335	0.06	0.43	0	55.18086

Table A-2: Summary statistics for DD2 groups

DD2 - Treatment (Military on BRAC-affected bases)						
Same as DD1 - Treatment						
DD2 - Comparison (Civilians in BRAC-affected PUMAs)						
Variable	Obs.	Weighted Obs.	Mean	Std. Dev	Min	Max
Commute Travel Time 2000-05 (min.)	1,546	155,681	23.50	24.67	0	185
Commute Travel Time 2006-10 (min.)	4,060	424,647	22.11	20.66	0	195
WP Worker Density (workers/sq. km)	7,202	738,699	1855.92	6995.61	0.3399474	163266.1
Age (yrs)	7,202	738,699	30.73	7.98	17	61
Age Squared (yrs^2)	7,202	738,699	1008.12	543.72	289	3721
Family Inc. ($10,000)	7,202	738,699	58.50	40.06	0	730.5
Education (yrs)	7,202	738,699	7.53	1.78	0	11
Female (0,1)	7,202	738,699	0.13	0.34	0	1
Veh. Per Adult in Household (No.)	7,202	738,699	1.14	0.63	0	6
Family Size (No.)	7,202	738,699	2.84	1.47	1	11
Married (0,1)	7,202	738,699	0.71	0.45	0	1
Immigrated to U.S. (0,1)	7,202	738,699	0.10	0.29	0	1
Hrs. worked per Wk (hrs.)	7,202	738,699	51.71	13.88	0	99
Kids in Household (No.)	7,202	738,699	1.00	1.17	0	9
Bus Density (bus workers/sq km.)	7,202	738,699	1.26	9.28	0	422.7533
Train Density (train workers/sq km.)	7,202	738,699	0.24	1.26	0	52.01862
Urban Household (0,1)	7,202	738,699	0.09	0.29	0	1
Rural Household (0,1)	7,202	738,699	0.17	0.38	0	1
WP Bus Density (bus workers/sq. km)	3,886	387,126	0.35	1.41	0	62.70433
WP Train Density (train wkrs/sq. km)	3,886	387,126	0.18	0.73	0	13.80383

Table A-3: Summary statistics for DD3 groups

DD3 - Treatment (All employed individuals in BRAC-affected PUMAs)						
Variable	Obs.	Weighted Obs.	Mean	Std. Dev	Min	Max
Commute Travel Time 2000-05 (min.)	50,837	5,234,032	24.86	21.81	0	196
Commute Travel Time 2006-10 (min.)	139,148	14,533,948	25.19	21.34	0	200
WP Worker Density (workers/sq. km)	189,985	19,767,980	2476.03	3503.28	0.2667204	194504.9
Age (yrs)	189,985	19,767,980	38.98	11.80	17	61
Age Squared (yrs^2)	189,985	19,767,980	1658.82	928.72	289	3721
Family Inc. ($10,000)	189,985	19,767,980	82.04	73.25	-19.998	1721
Education (yrs)	189,985	19,767,980	7.47	2.29	0	11
Female (0,1)	189,985	19,767,980	0.46	0.50	0	1
Veh. Per Adult in Household (No.)	189,985	19,767,980	1.23	0.71	0	6
Family Size (No.)	189,985	19,767,980	2.95	1.59	1	16
Married (0,1)	189,985	19,767,980	0.55	0.50	0	1
Immigrated to U.S. (0,1)	189,985	19,767,980	0.18	0.38	0	1
Hrs. worked per Wk (hrs.)	189,985	19,767,980	40.92	11.75	0	99
Kids in Household (No.)	189,985	19,767,980	0.87	1.13	0	9
Bus Density (bus workers/sq km.)	189,985	19,767,980	1.52	3.11	0	274.9268
Train Density (train workers/sq km.)	189,985	19,767,980	0.54	1.08	0	67.98153
Urban Household (0,1)	189,985	19,767,980	0.23	0.42	0	1
Rural Household (0,1)	189,985	19,767,980	0.07	0.25	0	1
WP Bus Density (bus workers/sq. km)	43,701	4,232,680	0.12	0.42	0	33.42399

WP Train Density (train wkrs/sq. km)	43,701	4,232,680	0.06	0.43	0	55.18086

DD3 - Comparison (All employed individuals in adjacent PUMAs)						
Variable	Obs.	Weighted Obs.	Mean	Std. Dev	Min	Max
Commute Travel Time 2000-05 (min.)	33,798	3,414,238	25.32	23.34	0	197
Commute Travel Time 2006-10 (min.)	89,601	9,191,007	25.25	22.43	0	200
WP Worker Density (workers/sq. km)	123,398	12,605,058	2790.01	4438.69	0.6389797	87211.6
Age (yrs)	123,399	12,605,245	39.42	11.89	17	61
Age Squared (yrs²)	123,399	12,605,245	1695.04	941.24	289	3721
Family Inc. ($10,000)	123,399	12,605,245	79.82	72.22	-19.998	1282
Education (yrs)	123,399	12,605,245	7.59	2.24	0	11
Female (0,1)	123,399	12,605,245	0.47	0.50	0	1
Veh. Per Adult in Household (No.)	123,399	12,605,245	1.25	0.72	0	6
Family Size (No.)	123,399	12,605,245	2.73	1.51	1	16
Married (0,1)	123,399	12,605,245	0.53	0.50	0	1
Immigrated to U.S. (0,1)	123,399	12,605,245	0.12	0.32	0	1
Hrs. worked per Wk (hrs.)	123,399	12,605,245	40.24	11.54	1	99
Kids in Household (No.)	123,399	12,605,245	0.77	1.07	0	9
Bus Density (bus workers/sq km.)	123,398	12,605,058	2.43	4.26	0	269.102
Train Density (train workers/sq km.)	123,398	12,605,058	0.66	1.49	0	45.13968
Urban Household (0,1)	123,399	12,605,245	0.21	0.41	0	1
Rural Household (0,1)	123,399	12,605,245	0.19	0.40	0	1
WP Bus Density (bus workers/sq. km)	56,807	5,658,206	0.16	0.50	0	26.93345
WP Train Density (train wkrs/sq. km)	56,807	5,658,206	0.12	0.45	0	13.67605

Table A-4: Summary statistics for DD4 groups

DD4 - Treatment (All employed individuals in BRAC-affected PUMAs)						
Same as DD3 Treatment						

DD4 - Comparison (All individuals non-BRAC-affected PUMAs with Military Bases)						
Variable	Obs.	Weighted Obs.	Mean	Std. Dev	Min	Max
Commute Travel Time 2000-05 (min.)	135,665	14,112,097	26.40	23.53	0	200
Commute Travel Time 2006-10 (min.)	366,093	39,686,549	25.83	22.03	0	200
WP Worker Density (workers/sq. km)	501,757	53,798,592	13758.7	24825.33	0.068135	545081.7
Age (yrs)	501,758	53,798,646	39.06	11.79	17	61
Age Squared (yrs²)	501,758	53,798,646	1664.99	931.10	289	3721
Family Inc. ($10,000)	501,758	53,798,646	79.35	71.56	-20.1	1774
Education (yrs)	501,758	53,798,646	7.34	2.35	0	11
Female (0,1)	501,758	53,798,646	0.46	0.50	0	1
Veh. Per Adult in Household (No.)	501,758	53,798,646	1.15	0.76	0	6
Family Size (No.)	501,758	53,798,646	3.02	1.76	1	31
Married (0,1)	501,758	53,798,646	0.51	0.50	0	1
Immigrated to U.S. (0,1)	501,758	53,798,646	0.29	0.45	0	1
Hrs. worked per Wk (hrs.)	501,758	53,798,646	40.22	11.48	0	99
Kids in Household (No.)	501,758	53,798,646	0.86	1.16	0	9
Bus Density (bus workers/sq km.)	501,757	53,798,592	13.00	44.88	0	484.5425
Train Density (train workers/sq km.)	501,757	53,798,592	1.25	5.30	0	112.8643
Urban Household (0,1)	501,758	53,798,646	0.13	0.33	0	1

Variable	Obs.	Weighted Obs.	Mean	Std Dev	Min	Max
Rural Household (0,1)	501,758	53,798,646	0.06	0.24	0	1
WP Bus Density (bus workers/sq. km)	86,043	8,362,252	0.49	1.51	0	88.33821
WP Train Density (train wkrs/sq. km)	86,043	8,362,252	0.33	1.36	0	48.78015

Table A-5: Summary statistics for IV-1 models

IV-1 (Employed individuals in BRAC-affected PUMAs)						
Variable	Obs.	Weighted Obs.	Mean	Std. Dev	Min	Max
Commute Travel Time 2000-05 (min.)	146,953	15,375,148	24.50	21.28	0	200
Commute Travel Time 2006-10 (min.)	146,953	15,375,148	2488.31	3591.86	0.27	194505
WP Worker Density (workers/sq. km)	146,953	15,375,148	26295.61	17062.55	1600	69700
Age (yrs)	146,953	15,375,148	23.86	4.82	9.09	58
Age Squared (yrs^2)	146,953	15,375,148	38.75	12.25	17	62
Family Inc. ($10,000)	146,953	15,375,148	1651.83	965.65	289	3844
Education (yrs)	142,742	14,857,231	85.35	76.17	-19.998	1721
Female (0,1)	146,953	15,375,148	7.47	2.27	0	11
Veh. Per Adult in Household (No.)	146,953	15,375,148	0.45	0.50	0	1
Family Size (No.)	142,742	14,857,231	1.24	0.71	0	6
Married (0,1)	146,953	15,375,148	2.87	1.61	1	16
Immigrated to U.S. (0,1)	146,953	15,375,148	0.52	0.50	0	1
Hrs. worked per Wk (hrs.)	146,953	15,375,148	0.18	0.39	0	1
Kids in Household (No.)	146,953	15,375,148	41.16	12.13	1	99
Bus Density (bus workers/sq km.)	146,953	15,375,148	0.83	1.12	0	9
Train Density (train workers/sq km.)	146,953	15,375,148	1.49	3.17	0	275
Urban Household (0,1)	146,953	15,375,148	0.51	1.07	0	68
Rural Household (0,1)	146,953	15,375,148	0.22	0.42	0	1
WP Bus Density (bus workers/sq. km)	146,953	15,375,148	0.07	0.25	0	1
WP Train Density (train wkrs/sq. km)	35,002	3,445,369	0.11	0.39	0	33
Commute Travel Time 2000-05 (min.)	35,002	3,445,369	0.05	0.36	0	38

Table A-6: Summary statistics for IV-2 models

IV - Drivers (All employed individuals who report driving to work in BRAC-affected PUMAs)						
Variable	Obs.	Weighted Obs.	Mean	Std. Dev	Min	Max
Commute Travel Time 2000-05 (min.)	132,778	13,773,195	25.66	20.19	1	195
Commute Travel Time 2006-10 (min.)	132,778	13,773,195	2456.52	3545.45	0	194505
WP Worker Density (workers/sq. km)	132,778	13,773,195	2456.52	3545.45	0	194505
Age (yrs)	132,778	13,773,195	26243.72	17179.93	1600	69700
Age Squared (yrs^2)	132,778	13,773,195	23.95	4.83	11	46
Family Inc. ($10,000)	132,778	13,773,195	39.11	12.05	17	62
Education (yrs)	132,778	13,773,195	1674.65	956.27	289	3844
Female (0,1)	131,492	13,622,651	85.78	75.08	-20	1721
Veh. Per Adult in Household (No.)	132,778	13,773,195	7.52	2.26	0	11
Family Size (No.)	132,778	13,773,195	0.45	0.50	0	1
Married (0,1)	131,492	13,622,651	1.26	0.70	0	6
Immigrated to U.S. (0,1)	132,778	13,773,195	2.92	1.59	1	16
Hrs. worked per Wk (hrs.)	132,778	13,773,195	0.54	0.50	0	1

	Obs.	Weighted Obs.	Mean	Std. Dev	Min	Max
Kids in Household (No.)	132,778	13,773,195	0.18	0.38	0	1
Bus Density (bus workers/sq km.)	132,778	13,773,195	41.18	11.54	1	99
Train Density (train workers/sq km.)	132,778	13,773,195	0.85	1.12	0	9
Urban Household (0,1)	132,778	13,773,195	1.48	3.09	0	275
Rural Household (0,1)	132,778	13,773,195	0.51	1.07	0	68
WP Bus Density (bus workers/sq. km)	132,778	13,773,195	0.22	0.42	0	1
WP Train Density (train wkrs/sq. km)	132,778	13,773,195	0.07	0.25	0	1
Commute Travel Time 2000-05 (min.)	31,401	3,027,274	0.11	0.37	0	33
Commute Travel Time 2006-10 (min.)	31,401	3,027,274	0.05	0.35	0	38

Table A-7: Summary statistics for IV-3 models

IV - Military (Military in BRAC-affected PUMAs)						
Variable	Obs.	Weighted Obs.	Mean	Std. Dev	Min	Max
Commute Travel Time 2000-05 (min.)	4,497	473,431	22.52	17.32	0	188
Commute Travel Time 2006-10 (min.)	4,497	473,431	793.54	1650.88	0	21337
WP Worker Density (workers/sq. km)	4,497	473,431	26172.1	16281.40	1600	69700
Age (yrs)	4,497	473,431	21.39	4.10	13	41
Age Squared (yrs²)	4,497	473,431	31.08	8.00	17	61
Family Inc. ($10,000)	4,497	473,431	1030.09	544.69	289	3721
Education (yrs)	4,497	473,431	62.52	40.39	2	679
Female (0,1)	4,497	473,431	7.58	1.81	0	11
Veh. Per Adult in Household (No.)	4,497	473,431	0.14	0.35	0	1
Family Size (No.)	4,497	473,431	1.16	0.63	0	6
Married (0,1)	4,497	473,431	2.88	1.50	1	11
Immigrated to U.S. (0,1)	4,497	473,431	0.70	0.46	0	1
Hrs. worked per Wk (hrs.)	4,497	473,431	0.09	0.29	0	1
Kids in Household (No.)	4,497	473,431	53.47	14.25	1	99
Bus Density (bus workers/sq km.)	4,497	473,431	1.04	1.20	0	8
Train Density (train workers/sq km.)	4,497	473,431	0.80	2.88	0	156
Urban Household (0,1)	4,497	473,431	0.24	0.73	0	15
Rural Household (0,1)	4,497	473,431	0.12	0.33	0	1
WP Bus Density (bus workers/sq. km)	4,497	473,431	0.16	0.37	0	1
WP Train Density (train wkrs/sq. km)	2,709	278,036	0.15	0.64	0	33
Commute Travel Time 2000-05 (min.)	2,709	278,036	0.04	0.46	0	17

Table A-8: Summary statistics for IV-4 models

IV - Military, Drivers (Military drivers in BRAC-affected Bases)						
Variable	Obs	Weight	Mean	Std. Dev.	Min	Max
Commute Travel Time 2000-05 (min.)	4,286	450,945	22.58	16.41	1	185
Commute Travel Time 2006-10 (min.)	4,286	450,945	786.06	1624.95	2	18010
WP Worker Density (workers/sq. km)	4,286	450,945	26142.13	16109.33	1600	69700
Age (yrs)	4,286	450,945	21.33	4.04	13	40
Age Squared (yrs²)	4,286	450,945	31.05	7.94	17	61
Family Inc. ($10,000)	4,286	450,945	1027.21	541.01	289	3721
Education (yrs)	4,286	450,945	62.16	40.22	2	679
Female (0,1)	4,286	450,945	7.59	1.81	0	11

Veh. Per Adult in Household (No.)	4,286	450,945	0.14	0.35	0	1
Family Size (No.)	4,286	450,945	1.17	0.63	0	6
Married (0,1)	4,286	450,945	2.86	1.49	1	11
Immigrated to U.S. (0,1)	4,286	450,945	0.70	0.46	0	1
Hrs. worked per Wk (hrs.)	4,286	450,945	0.09	0.29	0	1
Kids in Household (No.)	4,286	450,945	53.58	14.09	1	99
Bus Density (bus workers/sq km.)	4,286	450,945	1.04	1.19	0	8
Train Density (train workers/sq km.)	4,286	450,945	0.78	2.74	0	156
Urban Household (0,1)	4,286	450,945	0.24	0.72	0	15
Rural Household (0,1)	4,286	450,945	0.13	0.33	0	1
WP Bus Density (bus workers/sq. km)	4,286	450,945	0.16	0.36	0	1
WP Train Density (train wkrs/sq. km)	2,582	265,161	0.15	0.64	0	33
Commute Travel Time 2000-05 (min.)	2,582	265,161	0.04	0.46	0	17

Table A-9: Full Results of DD(D) Models

Formatting in progress!

Table A-10: Full Results of IV Models

Formatting in progress!