The Long Run Impact of Bombing Vietnam[♦]

Edward Miguel [*]
Gérard Roland [**]

First draft: January 2005

Abstract: We investigate the impact of U.S. bombing on later economic development in Vietnam. The Vietnam War featured the most intense bombing campaign in military history. We use a unique U.S. military dataset containing bombing intensity at the district level (N=585). We compare the heavily bombed districts to other districts, controlling for baseline demographic characteristics and district geographic factors. U.S. bombing does not have a statistically significant impact on long-run population density, poverty rates, infrastructure, or literacy in the 1990s. This finding is consistent with the view that institutions and geography are more important than initial stocks of physical and human capital for long run economic growth.

[♦] We are very grateful to Vietnam Veterans of America Foundation (VVAF), the Defense Security Cooperation Agency (DSCA), and the Technology Center for Bomb and Mine Disposal, Vietnam Ministry of Defense (BOMICO) for providing access to the U.S. military data, and in particular to Major Patrick Keane, Benjamin Reich, Michael Scheinkman, Bill Shaw, and Tom Smith. Pamela Jakiela, Paul Cathcart, Monika Shah, Rachel Polimeni, and Khuyen Nguyen provided splendid research assistance on this project. We are also grateful to Scott Gartner, Chang-Tai Hsieh, Chad Jones, Dean Karlan, Martin Ravallion and to numerous seminar participants in Harvard / MIT, the 2005 ASSA Meetings, and U.C. Riverside for suggestions and comments on this research.
[*] Department of Economics, University of California, Berkeley and NBER (email: emiguel@econ.berkeley.edu, phone: 1-510-642-7162)
[**] Department of Economics, University of California, Berkeley and CEPR (email: groland@econ.berkeley.edu, phone: 1-510-642-4321)

1. Introduction

The horrors inflicted by war are clear to all, and so are its disruptive effects for people's lives. Indeed, war displaces populations, destroys capital and infrastructure, and disrupts schooling, and can produce negative environmental impacts, damage the social fabric, endanger civil liberties, and create health and famine crises. Any of these effects could be argued to have impacts on economic growth and development, and their combined effect even more. Jean Drèze for one forcefully expresses the view that "[w]ars or rather militarism is the major obstacle to development in the contemporary world" (Drèze 2000: 1171).

In contrast, standard neoclassical economic growth theory yields ambiguous predictions as to the effect of war on long-run growth. To the extent that the main impact of war is to destroy existing physical capital and reduce human capital accumulation, neoclassical models predict rapid postwar catch-up growth, as an economy converges back to its steady state growth rate, resulting in no long-run growth impacts. However, war may also profoundly affect the quality of institutions, technology, and various social outcomes. The institutional effects of war may in turn have permanent effects on growth, either negative impacts as argued by Drèze, or positive. For instance, it is often argued that military research and development expenditures lead to faster technological progress, which may offset war damage. Wars may also promote state formation and nation building as was the case with the European nation states (Tilly 1975), and may induce social and political progress via greater popular participation. For instance, political enfranchisement has often been a byproduct of war historically (Keyssar 2000). Social and political progress may in turn enhance public goods provision. The net long run effect of war is thus unclear a priori on theory grounds alone.

Yet the long run economic impacts of war remain largely unexplored empirically, and this is so for a variety of reasons. One important issue is the difficulty of convincingly identifying war impacts on economic growth in the presence of endogeneity between violence and economic conditions, and possible omitted variable biases.[1] But a perhaps even more fundamental empirical limitation is the frequent lack of data on war damage and economic conditions in conflict (and post-conflict) settings.

We exploit a uniquely data rich historical episode to estimate the impact of war on long-run economic performance, the U.S. bombing of Vietnam (what Vietnamese call "the American War"). The Indochina War, centered in Vietnam, was the most intense episode of aerial bombing known in human history: "the United States Air Force dropped in Indochina, from 1964 to August 15, 1973, a total of 6,162,000 tons of bombs and other ordnance. U.S. Navy and Marine Corps aircraft expended another 1,500,000 tons in Southeast Asia. This tonnage far exceeded that expended in World War II and in the Korean War. The U.S. Air Force consumed 2,150,000 tons of munitions in World War II – 1,613,000 tons in the European Theater and 537,000 tons in the Pacific Theater – and 454,000 tons in the Korean War" (Clodfelter 1995). Thus Vietnam War bombing represented roughly three times as much (by weight) as both European and Pacific theater World War II bombing combined, and about thirteen times total tonnage in the Korean war. Given the prewar Vietnamese population of approximately 32 million, U.S. bombing translates into hundreds of kilograms of explosives per capita during the conflict.[2] Given the unprecedented intensity of U.S. bombing, subsequent economic impacts in Vietnam may plausibly represent an upper bound on bombing impacts on economic growth more generally.

This study employs an unusual U.S. military district-level dataset on total bombs, missiles, and rockets dropped in Vietnam.[3] The U.S. bombing of Vietnam was largely concentrated in a subset of regions: roughly 70% of all ordnance was dropped in only 10% of the 585 districts in the sample.

---

[1] Miguel et al (2004) present a discussion of related econometric concerns.
[2] For another comparison, the atomic bombs dropped at Hiroshima and Nagasaki had the power of 15,000 and 20,000 tons of TNT, respectively (Grolier 1995). Since General Purpose bombs – by far the most common type of bomb used in Vietnam and in our dataset – are approximately 50% explosive material by weight, the atomic bombs translate into roughly 30,000 to 40,000 tons of munitions. Measured this way, U.S. bombing in Indochina represents 100 times the combined impact of the Hiroshima and Nagasaki atomic bombs.
[3] The data on land mines are incomplete since we miss mines placed by U.S. ground forces. We thus do not focus on land mines in the analysis below.

Figure 1 shows the geographic location of the 10% most heavily attacked districts (in terms of bombs, missiles and rockets per km^2), and these are visibly scattered throughout the country.

The heaviest bombing took place in Quang Tri province in the central region of the country near the 17^{th} parallel, the former border between North Vietnam and South Vietnam during the war. Quang Tri province was basically bombed flat during the war, with most capital and infrastructure destroyed; only 11 out of 3,500 villages were left unbombed at the end of the war (Project RENEW report 2004: 3). Provinces immediately north and south of Quang Tri also received heavy U.S. bombing, although less than in Quang Tri. Coastal regions of North Vietnam, as well as some districts of Hanoi, were heavily bombed, while in the South, the so-called "Iron Triangle", the region adjacent to Cambodia near Saigon, was also heavily bombed. This region was the site of frequent incursions by North Vietnamese troops and Vietcong guerrillas into South Vietnam through the so-called Ho Chi Minh trail that ran from North Vietnam through Laos and Cambodia.

[INSERT FIGURE 1]

There are many reasons to think U.S. bombing could have major long-run impacts on Vietnamese development. We focus on three factors in particular in the empirical analysis, all linked to neoclassical growth theory. First of all, U.S. bombing displaced populations on a large scale, and this could potentially disrupt local economic activity if many individuals never returned home. Second, the destruction of roads, bridges and local infrastructure may have inhibited local commerce, and possibly pushed some later investment towards other regions not heavily damaged in the war. For instance, U.S. bombing during the Rolling Thunder campaign of the late 1960s "destroyed 65 percent of the North's oil storage capacity, 59 percent of its power plants, 55 percent of its major bridges" (Clodfelter 1995: 134).[4] Third, population displacement and the destruction of physical infrastructure, including classrooms, disrupted schooling for millions of Vietnamese. In terms of other factors, we do not have complete information on unexploded ordnance (UXO), landmines, or

[4] Refer to Tilford (1991: 155) for further details on the extent of U.S. bombing damage.

Agent Orange use, and do not focus on these in the main empirical analysis.[5] However, there is obviously a strong correlation between bombing and later UXO density.

In this paper, we exploit the extensive variation in U.S. bombing intensity across 585 Vietnamese districts to estimate long-run impacts of the war. In our main finding, we find no robust long term impacts of U.S. bombing on local population density, poverty rates, consumption growth, or infrastructure measures in the 1990s. If anything, the more heavily bombed districts have somewhat less poverty in the 1990s than other districts, and this result is robust to a variety of alternative specifications and samples. There is no effect of U.S. bombing on consumption expenditure levels in 1997/1998, but suggestive evidence of a moderate negative effect in 1992/1993, suggesting that there may have been negative short run bombing effects, but that these largely dissipated over time as a result of rapid catch-up growth. (To be clear, the welfare costs of the war in Vietnam – which led to the death of millions of civilians by all accounts – were massive, even if there are no long-run growth impacts.) We focus primarily on Vietnam's central and southern regions, areas where U.S. bombing was most intense and which were largely rural and at broadly similar levels of economic development in the early 1960s before the war. The analysis also includes baseline population density, and geographic and climatic characteristics as regression controls.

It is important to note that while this econometric strategy provides reliable estimates of differences across districts more and less affected by the war, our approach is unable to capture any aggregate nation-wide effects of the war on subsequent Vietnamese development. This is a potentially important issue to the extent that the war led to major national institutional or social changes, or if the cross-region spillovers of war are large. Still the rapid rate of economic growth in

[5] UXOs as well as landmines can impair the use of agricultural land, and are expensive to find and remove. While UXOs and landmines can seriously hurt farming families when an income earner is victimized, overall UXO and landmine injury rates in Vietnam during the 1980s and 1990s appear only moderate (Project RENEW report 2004: 16-18). The chemical agents used by the U.S. could also generate long term damage to population health and the environment. The most famous, Agent Orange, is a defoliant containing dioxins, and as late as 2001, traces of TCDD, the dioxin specific to Agent Orange, were still found in human blood in some areas (Hatfield report CITE). Deforestation itself could also negatively affect the environment by creating soil instability and affecting wildlife.

Vietnam since the early 1990s – at 6% on average between 1993 and 2003 (World Bank 2004) – suggests that any nation-wide impacts on long-run economic growth are unlikely to be negative.

Why does the most intense bombing campaign in human history seemingly have no adverse economic consequences 25 years later? There are a variety of explanations that we elaborate on below, based on this paper's empirical results as well as on our reading of the existing historical literature on Vietnam War.

First, most U.S. bombing targeted South Vietnam with the purpose of impeding the progress of enemy troops (both North Vietnamese Army and Vietcong guerrilla), and took place in rural areas (Tilford 1991: 105-6). These areas had little fixed infrastructure to destroy, and instead bombing often led to the destruction of forest and farmland, much of which could be expected to recover naturally over time. Even U.S. military planners recognized early in the war that "the agrarian nature of the [Vietnamese] economy precludes an economic collapse as a result of the bombing" (*Pentagon Papers* 1972: 232).

The North Vietnamese also employed a variety of ingenious strategies to limit the damage to the infrastructure that did exist. For instance, some industrial operations were dispersed across multiple sites (Kamps 2001: 70). According to Tilford (1991: 112) "[r]oads (such as they were) were quickly repaired. Bridges were bombed often but, in addition to being difficult to hit, were easily bypassed with dirt fords, underwater bridges, and pontoon bridges." In North Vietnam up to half a million people worked full time during the conflict rebuilding infrastructure destroyed by U.S. bombing (Herring 2002: 176). There was also a major Vietnamese government reconstruction effort after the war, with massive mobilization of labor and resources to rebuild damaged infrastructure and de-mine the countryside (World Bank 2002). The rebuilding of destroyed infrastructure could potentially have even generated "leapfrogging" effects in some cases, as newer technologies (e.g., in power generation) were introduced into war-damaged regions.

Second, population displacement seems to have been mostly temporary. Vietnamese communities developed elaborate responses to avoid injury during periods of intense U.S. bombing, including hiding for extended periods in well provisioned bomb shelters and in underground tunnels – thousands of miles of which were built during the war – while others fled temporarily before returning to rebuild (Herring 2002: 174-176).

Third, despite the war, large-scale school expansion and literacy campaigns were carried out during the 1960s and 1970s, especially in North Vietnam (Ngo 2004). Since school infrastructure was vulnerable to U.S. bombing, teachers and students often dispersed into small groups to avoid strikes, and these small schools had foxholes and helmets for students' protection during U.S. attacks (Duiker 1995, Nguyen Khac Vien 1981).

In the most closely related work, Davis and Weinstein (2002) find that the U.S. bombing of major Japanese cities during World War II had no long run impact on the population of those cities relative to prewar levels, and Brakman et al. (2004) find a similar result for postwar Germany. Organski and Kugler (1977, 1980) similarly find that the economic effects of the two world wars on a sample of mainly European countries tended to dissipate after only 15-20 years, for both capitalist and socialist economies, after which there was typically a return to prewar growth trends.

We view our results as complementary to the earlier studies. Vietnam was much poorer than either Japan or Europe during the 1960s and 1970s, and was an overwhelmingly rural country. Urban agglomeration effects thus likely played a less important role in postwar recovery patterns in Vietnam. Another major difference between Vietnam on the one hand and Japan on the other hand is that the former was a centrally planned economy postwar, while the latter was a market economy. This raises the question of what general lessons we can learn from these empirical results, since other market economies with different institutions might have reacted differently than Japan or Europe and other socialist economies might have reacted differently from Vietnam. Since institutions are often country specific, in our view it is only through the accumulation of evidence across many settings that researchers can create a convincing picture of war's long run effects on economic development.

The rest of the paper is organized as follows. Section 2 applies the neo-classical growth model to analyze the long run effect of war on economic growth. Section 3 presents the data. Section 4 discusses determinants of U.S. bombing, the main empirical analysis is presented in section 5, and the final section concludes and discusses broader lessons.

2. The Effects of War on Growth

To start, it is useful to organize thoughts using the textbook neo-classical Ramsey growth model:

$$Max\int_0^\infty u(C(t))e^{-\rho t}\,dt$$

$$\textbf{s.t. } \dot{K}(t) = AF(K(t), L(t), H(t)) - C(t) \qquad (1)$$

where *u(.)* is a concave utility function, *C(t)* is the consumption path in a particular economy or region, and ρ is the discount rate. The stock of capital *K(t)* in the region accumulates with savings *Y(t)–C(t)* where *Y(t)*= $AF(K(t), L(t), H(t))$, and where *L(t)* is labor and *H(t)* human capital. Parameter *A* captures institutional and technological characteristics of the economy. For simplicity, we assume no capital depreciation, assume that population grows at the exogenous rate *n*, and that the stock of human capital is exogenously given and stationary (although this is modified below). Assuming constant economies of scale, we can rewrite the optimization problem on a per capita basis (lowercase terms denote per capita values):

$$Max\int_0^\infty u(c(t))e^{-\rho t}\,dt$$

$$\textbf{s.t. } \dot{k}(t) = Af(k(t), h(t)) - c(t) - nk(t) \qquad (2)$$

The Euler equation is:

$$\frac{\dot{\lambda}}{\lambda} = \rho + n - Af'(k(t)) \tag{3}$$

where $f'(k(t))$ is the marginal product of capital and $\lambda(t)$ is the co-state variable. Taking into account the fact that at the optimum $\lambda = u'(c(t))$, the Euler equation can be rewritten as

$$\frac{\dot{c}(t)}{c(t)} = \sigma[Af'(k(t)) - \rho - n] \tag{4}$$

where σ is the intertemporal elasticity of substitution of consumption. The steady state in this economy (k^*, c^*) will be characterized by $\dot{k} = 0, \dot{c} = 0$ following from equations (2) and (4). Figure 1 depicts the steady state and phase diagram in (k, c) space.

[INSERT FIGURE 2]

Assume now that war leads to the partial destruction of the physical capital stock in a region i, such that postwar capital there is $\tilde{k}_i < k^*$, thus shocking the economy away from the steady state but leaving all parameters unchanged. In this case, capital will accumulate and consumption will grow until the steady state (k^*, c^*) is again reached. Instead now imagine there are two regions, region i where there is war damage ($\tilde{k}_i < k^*$) and region j where there is no war damage ($\tilde{k}_j = k^*$). The long-run capital stock and consumption level are identical in the two regions since none of the model parameters have changed. However, the region that suffered war damage experiences more rapid postwar consumption growth than the untouched region along the transition path back to the steady state, as one can see in equations (2) and (4).

Although we isolate the effect of a reduction in physical capital above for algebraic simplicity, postwar recovery patterns are theoretically analogous for human capital (see Barro and Sala-i-Martin 2003 for a full treatment of the two-sector growth model). A reduction in human capital levels in a war torn region will also lead to more rapid postwar accumulation of human capital there, though again there is no change in steady state outcomes provided that other model parameters are unchanged. We abstract away from issue of local population growth, in part because the usual benchmark assumption of free labor mobility largely did not apply in communist postwar Vietnam.[6]

Beyond diminishing physical and human capital stocks, war could also lead to institutional changes. Deterioration in national institutions postwar corresponds to $\widetilde{A} < A$, and equation (4) implies that steady state capital k^* must decline in this case. In particular, the locus $\dot{c} = 0$ will move to the left (as depicted by the dotted line in Figure 2), and by similar reasoning, we see from (2) that the $\dot{k} = 0$ curve shifts down. The new steady state is characterized by a lower long run level of both capital and consumption at (k', c'). By symmetric logic, a positive shift in *A* during the war leads to higher steady state capital and consumption for all regions. Of course, to the extent that conflict has an effect on the evolution of local institutional quality A_i for region i (i.e., not all relevant institutions are national in scope), long run growth rates could diverge across regions that experienced different war impacts.

3. The Data

We exploit a database assembled by the Defense Security Cooperation Agency (DSCA) housed at the National Archives in Record Group 218, called "Records of the U.S. Joint Chiefs of Staff". We obtained the data from the Vietnam Veterans of America Foundation (VVAF) with authorization from DSCA and the Technology Center for Bomb and Mine Disposal, Vietnam Ministry of Defense.

[6] See Davis and Weinstein (2002) for a discussion of various theories of economic geography and population agglomeration, and Barro and Sala-i-Martin (2003) for models of economic growth and population.

The database contains information on all ordnance dropped from U.S. airplanes and helicopters in Vietnam between 1965 and 1975,[7] as well as artillery fired from naval ships[8] and sea mines dropped. To our knowledge, the files we have embody the most complete, comprehensive and reliable summary available of U.S. and allied air and sea ordnance expended during the Vietnam War, although some of the original tape archives were reportedly damaged so up to several months of data may be missing (unfortunately we are unable to determine the precise extent of any damage to the archive). The data were originally recovered from U.S. aircraft mission logs, and then reported to U.S. Pacific Command and the Joint Chiefs of Staff. They were declassified in 1975 and provided to the Vietnamese government following the war. The Data Appendix discusses the data sources in greater detail.

The raw data include the location of the bombing, a summary bomb damage assessment (which we do not have access to), and the quantity of ordnance by category and type. Categories include general purpose bombs[9], cluster bombs, chemical, fuel air explosives, incendiary, rockets, missiles, projectiles, ammunition, and flares. Data entries are measured in the number of units rather than by weight. Since the source of the data is the U.S. Air Force and Navy, we miss anti-personnel landmines that were placed by Army ground forces, which probably accounts for a large share of U.S. landmines (and thus the landmine data are likely less reliable than the other data). The raw data were then geo-coded by VVAF using the current district boundaries employed in the 1999 Population and Housing Census, to yield the dataset used in the analysis. Examples of the raw bombing data are presented in Appendix Figures 1 and 2.

General purpose bombs are by far the most common ordnance category (Table 1). Average bombing intensity is high, with an average of 32.3 bombs, missiles, and rockets per km^2 nationwide,

[7] In particular, data come from the 1965-70 Combat Activities, Air (CACTA) and 1970-1975 South East Asia (SEADAB) databases.
[8] The Combat Naval Gunfire (CONGA) file.
[9] Usually, the Mark 82 and Mark 36 Destructor. General purpose bombs typically weighed between 500-750 lbs.

and there is extensive variation across districts in all ordnance categories. The distribution of bombs was skewed, with 10% of districts receiving nearly 70% of all bombs, missiles and rockets, and some districts receiving as much as 561 bombs per km^2.[10] The most intense attacks took place near the 17th parallel that formed the border between North and South Vietnam during the war. We focus at times on what we call the "Central Region" of the country, which as we define it includes 22 provinces and 229 districts, and includes nearly all districts in the top 10% most bombed group. This Central Region excludes the major cities of Da Nang, Saigon (now Ho Chi Minh City), Hanoi, and Haiphong as well as both the extreme north of the country bordering China and the southern Mekong Delta region. Bombing intensity in the Central Region is nearly double that for the nation as a whole. There is also considerably more variation in bombing intensity there (Table 1), and it was overwhelmingly rural at baseline (since the major cities are excluded, by construction) making it a particularly useful region to focus on in the analysis since there is less baseline socioeconomic variation than in the country as a whole.

[INSERT TABLE 1]

Figure 3 presents the geographic distribution of bombing intensity in Vietnam. The poor northwestern region of Vietnam was hardly bombed at all, in part because of the Johnson administration's reluctance to antagonize China by bombing Vietnamese regions near its borders (Tilford 1991: 153). While bombing intensity was highest near the 17th parallel, it was also high in the "Iron Triangle" region of South Vietnam adjacent to Cambodia, the endpoint of the Ho Chi Minh Trail, as well as in some parts of North Vietnam.

[INSERT FIGURE 3]

There is a positive and statistically significant correlation across all ordnance categories dropped in a district (Table 2). In the regression analysis below, we mostly employ total intensity

[10] Quang Tri district in Quang Tri province, which is only 6 km^2 in size, actually received over 3000 bombs per km^2 during the war, the highest in the dataset by far. We exclude this outlier in the empirical analysis below.

(per km^2) of bombs, missiles, and rockets, but given the substantial correlation with other ordnance categories (e.g. ammunition), this can be thought of as a good proxy for the overall intensity of local war activity; unfortunately, we do not have comparable ordnance data for the North Vietnamese Army or the Vietcong guerrillas.

[INSERT TABLE 2]

We obtained provincial population density in 1960-61 from both South Vietnam and North Vietnam government sources (described in the Data Appendix), and use those data as baseline controls in the main regressions (Table 3). Note the sharp increase in population density from 1960-61 to the 1999 Vietnam Population and Housing Census.[11] A variety of local geographic and climatic characteristics, including proportion of land at high altitude, total district land area, average district temperature and precipitation, location in former South Vietnam, and proportion of land in 18 different soil type categories, are also included as district controls in most specifications to, at least in part, control for agricultural productivity, as well as certain factors potentially affecting military operations (e.g., altitude).

We focus on several economic outcomes. Poverty rate estimates are from Minot et al. (2003), who uses the local regression method in Elbers et al (2003). This method matches up 1999 Population and Housing Census data – which has excellent coverage but limited household characteristics – with detailed 1997/8 Vietnam Living Standards Survey (VLSS) household data. Log-linear regressions of real cost-of-living-adjusted per capita consumption expenditures on 17 household characteristics included in both the census and VLSS are then carried out and the results used to compute predict household consumption (details of the procedure are included in the Data Appendix). The poverty rate is defined as the percentage of district population estimated to be living on less than 1,789,871 Vietnamese Dong per year, the official national poverty line, and

[11] We also obtained baseline data on prewar rice paddy yields by province, but these are not used because they are thought be unreliable (Banens 1999, Herring 2002).

approximately 41% of the population meets this criterion (Table 3). The 1999 census also provides detailed information on household access to infrastructure, including electricity (71% of households nationwide have access to electricity), and literacy (88% of respondents report being literate).

Finally, we obtained per capita consumption expenditure data from both the 1992/3 and 1997/8 waves of the VLSS, although this data is only available for a sample of households in a subset of 166 districts, reducing the sample (the districts with VLSS data are presented in Appendix Figure 3); we focus on province level averages using the smaller VLSS sample. This data allows us to assess consumption growth during the rapid economic expansion of the 1990s. The VLSS also contains retrospective information on migration patterns, and membership in local veterans groups, that we exploit in the empirical analysis.

[INSERT TABLE 3]

4. Determinants of U.S. Bombing Intensity

Before presenting the econometric analysis, we briefly discuss the existing literature on U.S. bombing strategy during the Vietnam war. A distinction is often made between the nature of bombing of North Vietnam and South Vietnam. U.S. bombing in North Vietnam is considered largely *strategic bombing*, targeting transportation capabilities (e.g., airfields, railroads, bridges, ports, roads), as well as military barracks, industrial plants, and storage depots (Clodfelter 1995: 134). The selection of targets in North Vietnam was directly supervised by Washington officials on a weekly basis during the Johnson administration’s “Rolling Thunder” air campaign (Littauer et al., 1972: 37), and the number of approved targets regularly fell below the requests of the military, with the bombing of Hanoi, Haiphong and areas near the Chinese border ruled out. A far broader set of targets in North Vietnam was approved under the Nixon administration’s “Linebacker” bombing campaign, however, including targets in the North’s main population centers.

Bombing in South Vietnam, in contrast, was typically *interdiction bombing*, which aimed to disrupt enemy troop movements and support U.S. ground troop operations, rather than explicitly to destroy infrastructure (Littauer et al 1972: 55; Schlight 1988: 292). Bombing in South Vietnam was more intense on average than in the North. Below we present empirical results broken down by the former North and South Vietnam, to investigate whether the different nature of bombing led to different long-run impacts.

[INSERT TABLE 4]

Prewar province population density in 1960-61, and an indicator for former South Vietnam regions, are not significantly related to our main measure of bombing intensity, total U.S. bombs, missiles and rockets per km^2 (Table 4, regression 1). All empirical results are similar if we consider only the intensity of general purpose bombs, the major ordnance category (results not shown). District altitude, land area and temperature are not significantly related to bombing, but average precipitation is positively associated with bombing. This might reflect the fact that jungle areas often used by Vietcong troops were more heavily bombed by the U.S. Similarly, the coefficient estimate on initial population density is negative (though small), suggesting that more urbanized regions were bombed somewhat less on average than the countryside (regression 2). The results are largely unchanged when Quang Tri province, the most heavily bombed province, is excluded, and standard errors fall considerably in that case (regression 3).

We next focus on the Central Region which experienced the most intense U.S. bombing. Results are broadly similar except that population density is not a significant predictor of U.S. bombing when Quang Tri province is included in the sample. Figure 4 graphically presents the weak negative relationships between baseline 1960-1 population density and U.S. bombing intensity for both All Vietnam (panel A) and for the Central Region (panel B).

Most of the existing historical literature is consistent with this finding of no robust correlation between initial population density and bombing intensity (Nalty 2000: 83), though some suggest that poorer areas were somewhat more likely to be hit by U.S. bombing: "[i]n the remoter, sparsely populated regions often used by the NLF/NVA [Vietcong/North Vietnamese Army] for staging, regroupment, and infiltration, area saturation bombing is common" (Littauer et al 1972: 10-11). To the extent that some dimension of baseline district socioeconomic conditions remain unexplained by our regression controls, this pattern suggests that, if anything, omitted variable bias would lead us to overstate the impact of U.S. attacks in increasing poverty.

[INSERT FIGURE 4]

5. The long run impact of bombing Vietnam

5.1 Impacts on population density

We consider bombing impacts at both the province and district levels. There are a number of reasons to consider outcomes at the more aggregated province level. First, U.S. bombing of one district could generate externalities for other nearby districts. Provincial level regressions are thus one way to partially capture these externalities (although this specification still misses any cross-province externalities). Second, the main baseline 1960-61 population density control is at the province level, and thus for population density figures at least, the analysis utilizes a true panel design. Finally, the province results serve as a robustness check for the district level analysis.

Total U.S. bombing intensity in a province during 1965-1975 is not significantly related to province population density in 1999 (Table 5, regression 1), with a point estimate of -0.28 (standard error 0.27). Provinces that had high population density in 1960-61 also tend to have high density in 1999 (the point estimate on 1960-61 density is 1.86, standard error 0.09), and former South Vietnam has somewhat higher 1999 population density than former North Vietnam, although that difference is not statistically significant.

In specifications including Quang Tri province (Table 5, regression 2) or excluding it (regression 3), total U.S. bombing intensity is not statistically significantly related to 1999 district population density. The district's total geographic area is negatively related to 1999 population density, perhaps in part since rural districts tend to be large.[12]

[INSERT TABLE 5]

Restricting attention to the largely rural Central Region, U.S. bombing intensity is negatively related to 1999 population density at the province level (Table 5, regression 4), but the relationship is much weaker and is statistically insignificant at the district level (regressions 5 and 6). The signs of the coefficient estimates are similar in both the All Vietnam and Central Region specifications. Figure 5 presents the province level relationships graphically.

[INSERT FIGURE 5]

Similarly, there is no statistically significant effect of U.S. bombing intensity on 1999 district population density in a variety of other samples and specifications, including in former North Vietnam (Table 6, regression 1) and South Vietnam (regression 2); in rural areas (districts with baseline 1960-1 population density less than 200 per km^2, regression 3) and urban areas (regression 4), the latter being the specification most closely related to Davis and Weinstein (2002) and Brakman et al (2004); when province fixed effects are included for both All Vietnam (regression 5) and the Central Region (regression 6); and using an alternative measure of bombing intensity (regressions 7 and 8). The bottom line is that more heavily bombed districts are indistinguishable from other districts in terms of population density 25 years after the end of fighting. Of course, even though the baseline population density figures and detailed district controls partially address omitted variable concerns – as does the restriction to the Central Region sample – we cannot entirely rule out the possibility that omitted variable bias is in part driving the estimated relationships, unfortunately.

[INSERT TABLE 6]

[12] It is not immediately clear, however, how good a proxy district size is for pre-war population density since district definitions have changed since the war.

We next trace out effects on population density over time during the 1990s. Using data from Vietnamese Statistical Yearbooks, we find no effect of bombing intensity on province population growth rates from 1990 to 2000 (Table 7, Panel A). As was the case for 1999, there is no statistically significant effect of U.S. bombing on province population density in any year from 1990 to 2000 (results not shown). When we group districts by U.S. bombing intensity, the evolution of population density across 1990, 1992, 1994, 1996, 1998, and 2000 is largely parallel across all four bombing intensity quartiles (Figure 6), so there is no evidence for rapid catch population growth in more heavily bombed areas. Note that disaggregated population density figures, as well as other official demographic and economic measures, are largely unavailable for the 1970s and 1980s, preventing us from extending this analysis back to the immediate postwar period, unfortunately.

[INSERT TABLE 7]

[INSERT FIGURE 6]

It remains theoretically possible that this lack of effects on postwar population density is due to large postwar inflows of migrants into the heavily bombed districts, but we find no evidence that this is the case. Using the VLSS data, there is no statistically significant difference between the proportion of 1997/8 individuals not born in their current village of residence as a function of U.S. bombing intensity (Table 7, panel B), in either the All Vietnam or Central Region samples, and whether or not Quang Tri province is excluded. Note the large positive coefficient estimate on the former South Vietnam indicator variable, which indicates that households in the former South Vietnam were significantly more likely to relocate – either voluntarily or as part of the central government's postwar relocation program – than those in the North.

U.S. bombing intensity is, however, significantly positively related to the proportion of current province inhabitants who are members of a war veterans association in 1997/8 in certain specifications (Table 7, panel C), suggesting some persistence in residential patterns from the war period through the late 1990s. Not surprisingly, the proportion of war veterans is consistently lower in the former South Vietnam, since official veterans associations exclude those who served in the old anti-communist South Vietnamese military.

5.2 Impacts on poverty, consumption, and capital

Total U.S. bombing intensity is negatively associated with 1999 poverty rates in most regressions (Table 8), and in some cases the effect is statistically significant. While the point estimate of bombing intensity on the poverty rate is negative in all specifications, point estimates are more consistently negative for the All Vietnam specifications (regressions 1-3) than for the Central Region (regressions 4-6). This pattern may in part reflect the fact that some of the poorest provinces in Vietnam, those in the northwest, were rarely bombed by the U.S. due to their proximity to China, potentially generating a spurious negative correlation; recall that these provinces are excluded from the Central Region sample. The relationship between bombing intensity and poverty at the province and district levels are presented graphically in Figures 7 and 8, respectively.

[INSERT TABLE 8]

[INSERT FIGURE 7]

[INSERT FIGURE 8]

In our preferred specification, using district level data for the Central Region sample (Table 8, regression 5), the coefficient estimate on total U.S. bombing intensity is -0.00018 (standard error 0.00020). To get an idea of the magnitude of bombing impacts on later poverty, first consider the effect of the change from zero bombing up to the average bombing intensity in the Central Region, which is an intensity of 56.7 bombs, missiles, and rockets per km^2. The average effect, in this sense, is (56.7)*(-0.00018) = -0.010. This is a very small average effect, a reduction in the poverty rate by 1.0 percentage point, and it is not statistically significant. In terms of how precise the estimate is, the 95% confidence band ranges from -0.00018 – 2*0.00020 = -0.00058, up to -0.00018 + 2*0.00020 = 0.00022. Thus again considering the effect of going from zero bombing up to the average intensity of

56.7, the 95% confidence band range of estimates is (56.7)*(-0.00058) = -0.033 to (56.7)*(0.00022) = 0.012. In other words, plausible average effects range from a three percentage point reduction in poverty up to a one percentage point increase in poverty in the Central Region, on a base poverty rate in that region of 43%. This is a reasonably tight range of estimates, and we can thus rule out almost any increase in poverty due to U.S. bombing.

In terms of other determinants of 1999 poverty, a higher initial 1960-1 population density is associated with lower poverty rates in 1999 as expected (for instance, in Table 8, regression 2); the former South Vietnam has far lower poverty rates than former North Vietnam (point estimate -0.18, standard error 0.05), perhaps in part reflecting income differences already in place upon reunification in 1975, as well as faster economic growth in the South since the implementation of *doi moi* economic reforms since the 1980s; and high altitude districts also have substantially higher poverty rates, as do geographically larger districts and those with greater average precipitation.

More heavily bombed districts in Vietnam if anything have somewhat lower poverty rates than other districts 25 years after the "American War". There are moderately sized negative, but not statistically significant, effects of bombing in both former North Vietnam (Table 9, regression 1) and South Vietnam (regression 2). Effects are similarly negative in both rural areas (districts with baseline 1960-1 population density less than 200 per km^2, regression 3) and urban areas (regression 4), although point estimates are slightly more negative for the more urban areas. Point estimates become even more negative and statistically significant when province fixed effects are included, for both All Vietnam (regression 5) and the Central Region (regression 6), and when using an alternative measure of bombing intensity (regressions 7 and 8).

[INSERT TABLE 9]

We next explore related relationships using the more detailed household consumption expenditure data from the VLSS. Consistent with the 1999 poverty findings, average household consumption expenditures per capita in 1997/98 are somewhat higher in areas that were more heavily bombed, both for All Vietnam and the Central Region (Table 10, panel A, regressions 1-4), although the estimated effects are typically not statistically significantly different from zero. However, the pattern shifts when examining earlier consumption: average consumption expenditures per capita in 1992/93 are actually slightly lower in more heavily bombed districts (panel B, regressions 1-4), although once again these effects are not robustly significant. This suggests that more heavily bombed areas were poorer than other areas in the immediate aftermath of the war, but that they later caught up during the Vietnamese economic boom of the 1990s, in line with the neoclassical growth model's predictions about consumption growth along the transition path to the steady state. The positive estimated impact of U.S. bombing on consumption growth rates from 1992/3 to 1997/8 (panel C) is consistent with this view.

[INSERT TABLE 10]

In order to explore the sources of differential growth performance, we next examine infrastructure across Vietnamese districts in the 1990s. Infrastructure investment decisions in Vietnam in the 1980s and 1990s are likely to reflect both central government redistributive goals as well as potential private profits, especially in the aftermath of economic reforms, and it is difficult to disentangle these motives. There is a positive relationship between U.S. bombing intensity and 1999 access to electricity across all three All Vietnam specifications (Table 11, regressions 1-3). The relationship does not hold in the Central Region (regressions 4-6), however, although point estimates remain positive, and taken together this is suggestive evidence for technological "leapfrogging" in heavily bombed regions.

[INSERT TABLE 11]

The final channel is human capital. There is no statistically significant impact of bombing on either province or district literacy rates in 1999, an important proxy for human capital investments (Table 12). Thus taking these last two results together, there is no evidence that more heavily bombed districts have either less physical infrastructure or human capital stocks 25 years after the end of the war, suggesting rapid postwar recovery.

[INSERT TABLE 12]

6. Conclusion

There are no robust long run impacts of U.S. bombing on local population density or poverty rates in Vietnam 25 years after the end of the "American War". If anything, the bulk of the empirical results point to moderate reductions in poverty, and possibly somewhat better electricity access, in the areas more affected by U.S. bombing. Any adverse short-run effects of the most intense bombing campaign in history appear to have completely dissipated after 25 years.

This main empirical result is consistent with recent findings in macroeconomics that capital and infrastructure investments matter less to long term economic growth than institutions and geography (for instance, see Hall and Jones 1999, and Acemoglu et al. 2002). Indeed, while institutions may be affected by war, they are often very resilient and may even become stronger as a result of conflict. Countries with "pro-growth" institutions appear able to recover rapidly from war, after initial investments to erase war damage.

However, as discussed above, our econometric approach – comparing more heavily bombed districts to others – cannot estimate any nation-wide effect on Vietnamese economic development due to the war, as the counterfactual – Vietnamese income levels in the absence of the "American war" – is impossible to reconstruct. If the regions not greatly affected by the war assisted the more heavily bombed regions through postwar resource transfers, differences between the more and less heavily bombed areas would be dampened but overall Vietnamese growth rates could still have fallen. On the other hand, the war undoubtedly fostered a strong sense of nationalism, and accelerated the development of capable North Vietnamese institutions, and both of these effects may have contributed to faster postwar economic recovery. The legacy of war has clearly not prevented

Vietnam from achieving rapid economic growth: Vietnamese economic growth in terms GDP per capita has recently been among the fastest in the world, at a healthy 6% per year between 1993 and 2003 (World Bank 2004). This is probably faster than prewar growth (at least for South Vietnam where there is some limited data, although it is of uncertain reliability), suggesting that average Vietnamese institutional quality may, if anything, have improved as a result of the war, although this is of course speculative.

Still, in our view, the broader lessons of this paper for understanding war's impacts on economic growth remain unclear. Unlike many other poor countries, the postwar Vietnamese communist regime benefited from strong, centralized political institutions able to mobilize vast human and material resources in the reconstruction effort. Vietnam also emerged from war out of a long struggle for national liberation against a series of foreign occupiers (first the French, then the Japanese briefly, and finally the U.S.), an experience that provided its postwar leaders considerable nationalist political legitimacy.

In contrast, the bulk of wars in the world today are civil conflicts, which may exacerbate political and social divisions rather than strengthening national institutions, as was apparently the case in Vietnam.[13] The world's most conflict prone region today is Sub-Saharan Africa, where states are notoriously weak (Herbst 2000). In such a setting, postwar reconstruction may drag on far longer than in Vietnam (or in Japan and Western Europe, where postwar political institutions were also strong) leading to more persistent adverse legacies of war. Due to the uniqueness of each nation's institutions, politics, and history, further empirical evidence accumulated across a variety of cases is probably needed before making general claims about the effects of war on long run institutional development and economic growth.

[13] The conflict in Vietnam was actually a combination of a war of national liberation and a civil conflict between the North and the South, but the political rhetoric of the victorious North usually emphasized the former.

References

Banens, Maks. (1999). "Vietnam: a Reconstitution of its 20th Century Population History." *Quantitative Economic History of Vietnam 1900-1990: An International Workshop*. Bassino, Jean-Pascal, Jean-Dominique Giacometti, and Konosuke Odaka (eds.). Institute of Economic Research: Hitotsubashi University.

Barro, Robert J., and Xavier Sala-i-Martin. (2003). *Economic Growth (Second Edition)*. MIT Press: Cambridge MA.

Carter, G. A. and J.W. Ellis, Jr. 1976. *User's Guide to Southeast Asia Combat Data*. R-1815-ARPA. Santa Monica, CA: RAND Corporation.

Clodfelter, Mark. (1989). *Limits of Air Power*. New York: Free Press.

Clodfelter, Michael. (1995). *Vietnam in Military Statistics: A History of the Indochina Wars, 1772-1991*. Jefferson, NC: McFarland.

Doleman, Edgar C., Jr. (1984). *Tools of War*. Boston: Boston Publishing Company.

Davis, Donald, and David Weinstein. (2002). "Bones, Bombs, and Break Points: The Geography of Economic Activity", *American Economic Review*, 92(5), 1269-1289.

Drèze, Jean. (2000). "Militarism, Development and Democracy", *Economic and Political Weekly*, April, 1171-1183.

Duiker, William. (1995). *Sacred War: Nationalism and Revolution in a Divided Vietnam*. New York: McGraw-Hill.

Elbers, C., J. Lanjouw and P. Lanjouw. (2003). "Micro-Level Estimation of Poverty and Inequality." *Econometrica*, 71 (1), 355-364.

Federation of American Scientists (FAS) (2004). *United States Weapons Systems*. Retrieved 8/04/04 from: http://www.fas.org/man/dod-101/sys/index.html.

General Statistical Office. (2000). *Vietnam Living Standards Survey 1997-1998*. Statistical Publishing House, Hanoi.

Gilster, Herman L. (1993). *The Air War in Southeast Asia: Case Studies of Selected Campaigns*. Maxwell Air Force Base, AL: Air University Press.

Herring, George C. (2002). *America's Longest War: The United States and Vietnam, 1950-1975* (Fourth Edition), McGraw-Hill: Boston.

Kamps, Charles Tustin. (2001). "The JCS 94-Target List: A Vietnam Myth That Still Distorts Military Thought." *Aerospace Power Journal*. 15(1): 67-80. (http://www.airpower.maxwell.af.mil)

Keyssar, Alexander. (2000). *The Right to Vote: The Contested History of Democracy in the United States*. New York: Basic Books.

Knight, Malcolm , Loayza, Norman and Delano Vilanueva (1996) "The peace dividend: military spending cuts and economic growth" World Bank Policy research Working Papers.

Littauer, Raphael and Norman Uphoff (Editors) (1972). *The Air War in Indochina*. Revised Edition. Boston: Beacon Press.

Miguel, Edward, Shanker Satyanath, and Ernest Sergenti. (2004). "Economic Shocks and Civil Conflict: An Instrumental Variables Approach", *Journal of Political Economy*, 112(4), 725-753.

Minot, Nicholas, Bob Baulch, and Michael Epprecht. (2003). *Poverty and inequality in Vietnam: Spatial patterns and geographic determinants*. International Food Policy Research Institute and Institute of Development Studies.

Momyer, William W. (1978). *Air Power in Three Wars*. Washington, DC: Dept. of Defense, Dept. of the Air Force.

Mrozek, Donald J. (1989). *Air Power and the Ground War in Vietnam*. Washington, DC: Pergamon-Brassey's International Defense Publishers.

Nalty, Bernard C. (2000). *Air War Over South Vietnam: 1968-1975*. Washington, DC: United States Air Force.

National Institute of Statistics. (1959-1965). *Statistical Yearbook of Vietnam*. Vols. 8-12. Saigon.

Ngo, Thi Minh. (2004). "Education and Agricultural Productivity in Vietnam", unpublished working paper, LSE.

Nguyen Khac Vien. (1981). *Contemporary Vietnam (1858-1980)*. Edited by R.River. Hanoi: Foreign Language Publishing House.

Nichols, John B. & Barrett Tillman. (1987). *On Yankee Station: The Naval Air War Over Vietnam*. Annapolis: Naval Institute Press.

Ordnance Shop (2004). *Weapons*. Retrieved August 4, 2004 from the World Wide Web: http://www.ordnance.org/weapons.htm.

Organski, A.F.K., and Jacek Kugler. (1977). "The Costs of Major Wars: The Phoenix Factor", *American Political Science Review*, 71(4), 1347-1366.

Organski, A.F.K., and Jacek Kugler. (1980). *The War Ledger*, Chicago: University of Chicago Press.

Parsch, Andreas (2003). *Designations of U.S. Aeronautical and Support Equipment*. Retrieved 8/04/04 from: http://www.designation-systems.net/usmilav/aerosupport.html.

Pentagon Papers: The Defense Department History of United States Decisionmaking on Vietnam (1972). Gravel Ed. Vol. 4. Boston: Beacon Press.

Project RENEW Report. (2004). "A Study of Knowledge-Awareness-Practices to the Danger of Postwar Landmines/Unexploded Ordnance and Accidents in Quang Tri Province, Vietnam" (www.vietnam-landmines.org).

Schamel, Charles E., comp. 1996. "A Finding Aid to Records Relating to American Prisoners of War and Missing in Action from the Vietnam War Era, 1960-1994." Records Information Paper 90. Washington, DC: National Archives and Records Administration.

Schlight, John. (1988). *War in South Vietnam: the Years of the Offensive, 1965-1968*. Washington, DC: Office of Air Force History, US Air Force.

Smith, John T. (1998). *Linebacker Raids: the Bombing of North Vietnam*. Wellington House, London: Arms & Armour Press.

Smith, John T. (1994) *Rolling Thunder: The American Strategic Bombing Campaign Against North Vietnam, 1964-68.* Walton on Thames, Surrey, England: Air Research Publications.

Smith, Tom. 2001. "Southeast Asia Air Combat Data." *DISAM Journal*, 24 (Winter): 19-20. (www.disam.dsca.mil)

Tilford, Earl H., Jr. (1991). *Setup: What the Air Force Did in Vietnam and Why*. Maxwell Air Force Base, AL: Air University Press.

Tilly, Charles. (1975). *The Formation of National States in Western Europe*. Princeton University Press: Princeton.

United Nations Mine Action Service (UNMAS) (2004). *Vietnam Country Profile*. Retrieved 8/04/04 from: http://www.mineaction.org/countries/countries_overview.cfm?country_id=826.

World Bank. (2002). *Vietnam Development Report 2002: Implementing Reforms for Faster Growth and Poverty Reduction*. World Bank: Hanoi.

Figure 1: Map of Vietnam – 10% of districts with the highest total U.S. bombs, missiles, and rocket intensity (per km^2) shaded

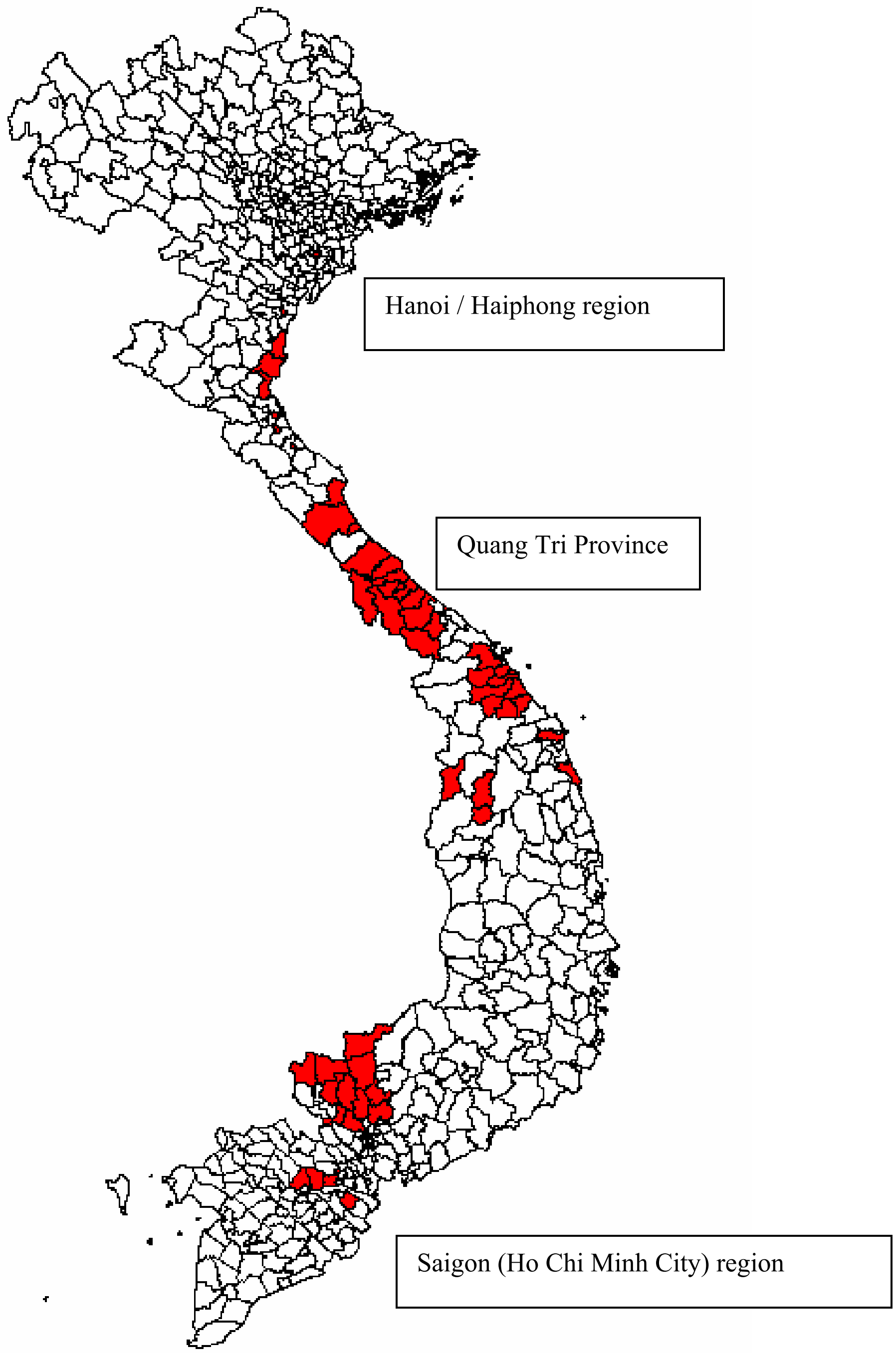


Figure 2: Phase diagram for the Ramsey model,
in per capita consumption (c) versus per capita physical capital (k) space

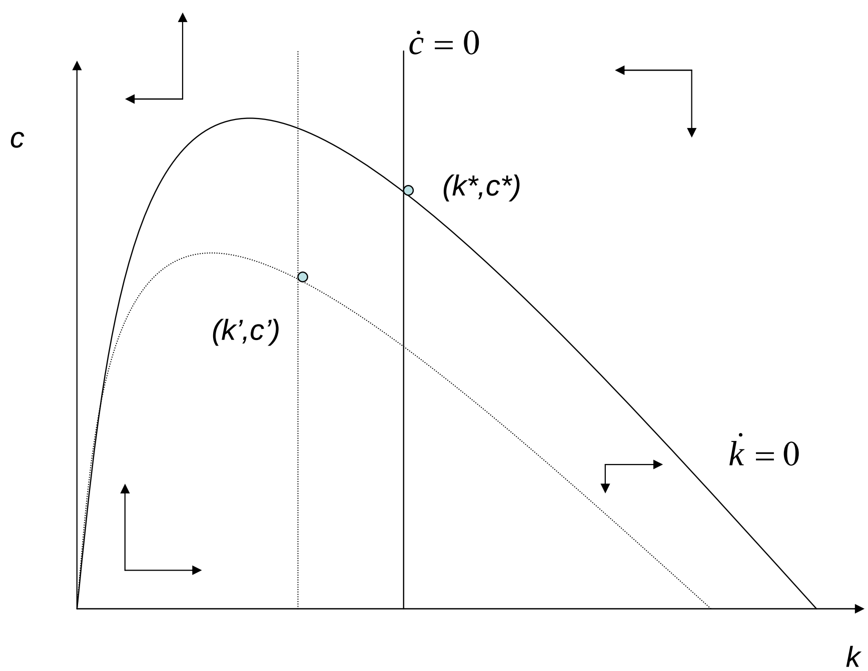


Figure 3: Map of Vietnam – Total U.S. bombs, missiles, and rocket intensity per km^2
(20 quantiles, darker colors denote higher intensity districts)

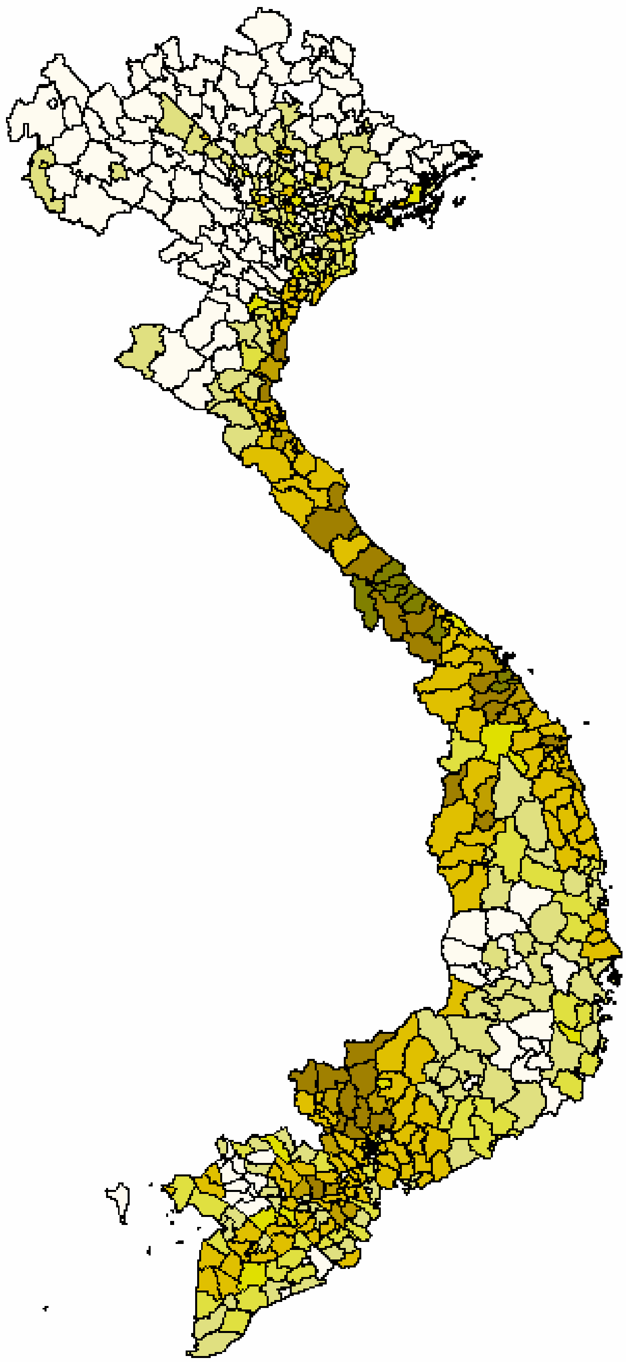
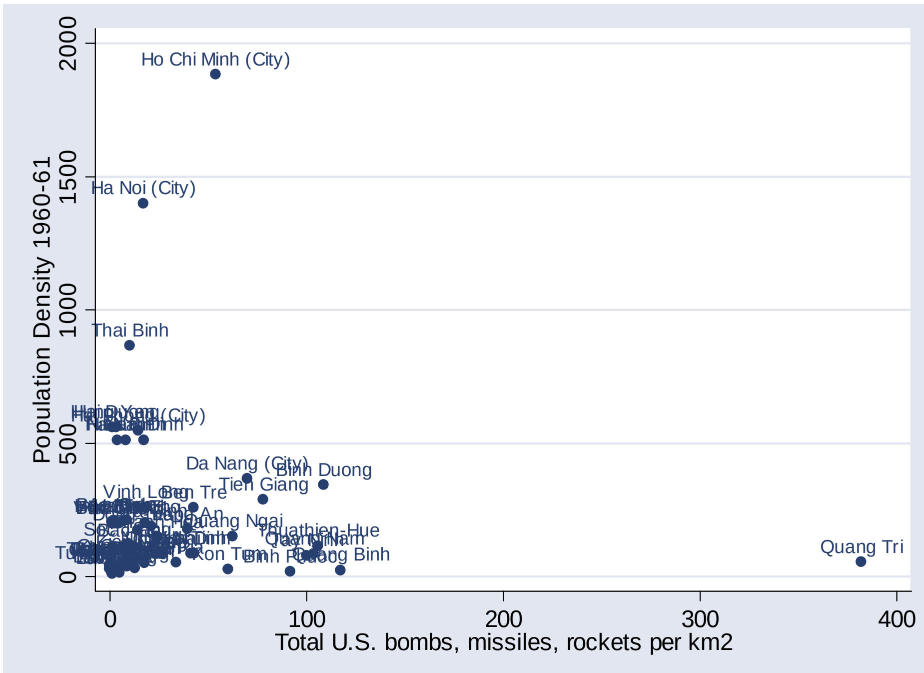


Figure 4: 1960-61 province population density vs.
Total U.S. bombs, missiles, and rocket intensity per km^2 in the province

(a) All Vietnam



(b) Central Region

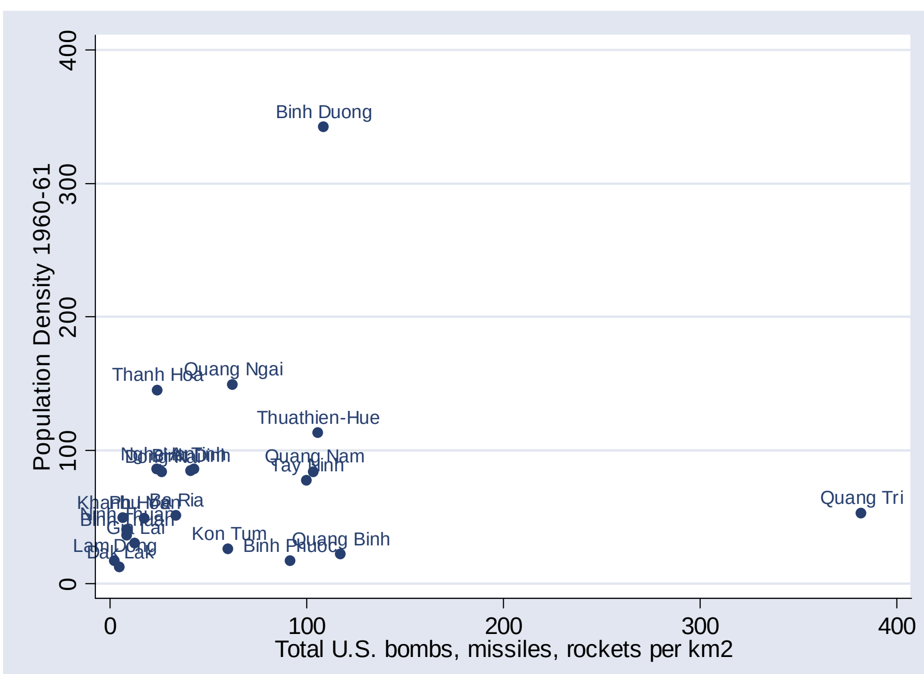
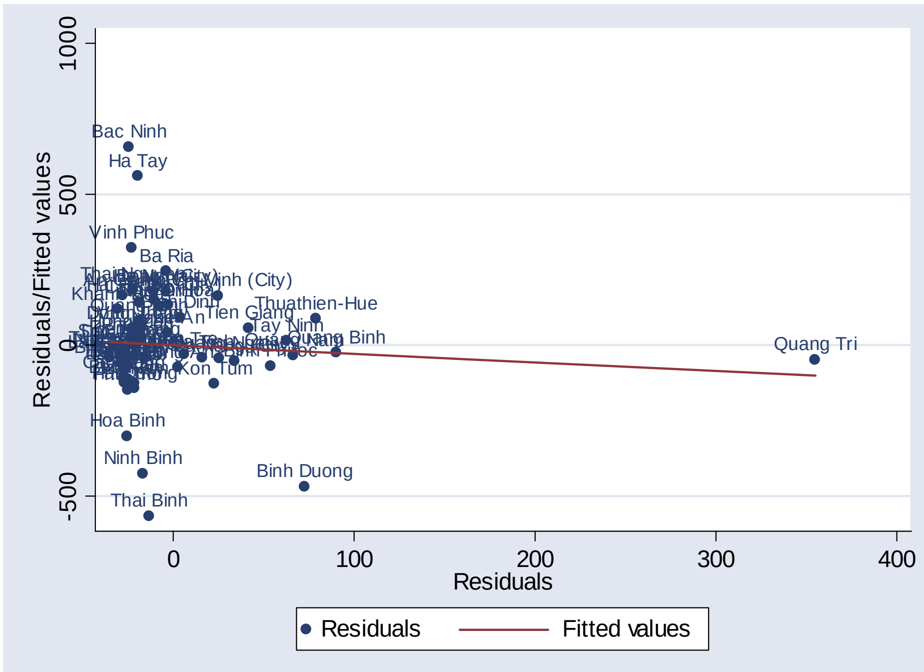


Figure 5: 1999 province population density vs.
Total U.S. bombs, missiles, and rocket intensity per km^2 in the province

(a) All Vietnam – conditional on 1960-61 province population density, South Vietnam indicator



(b) Central Region – conditional on 1960-61 province population density, South Vietnam indicator

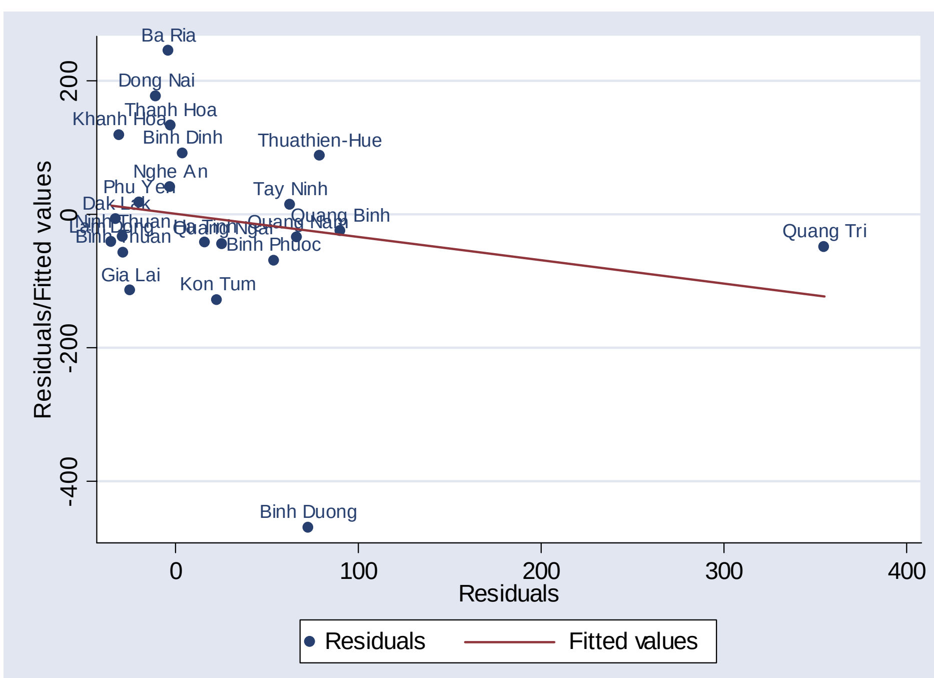


Figure 6: 1990-2000 Population Density
by Quartiles of total U.S. Bombs, missiles and rocket intensity per km^2 in the province

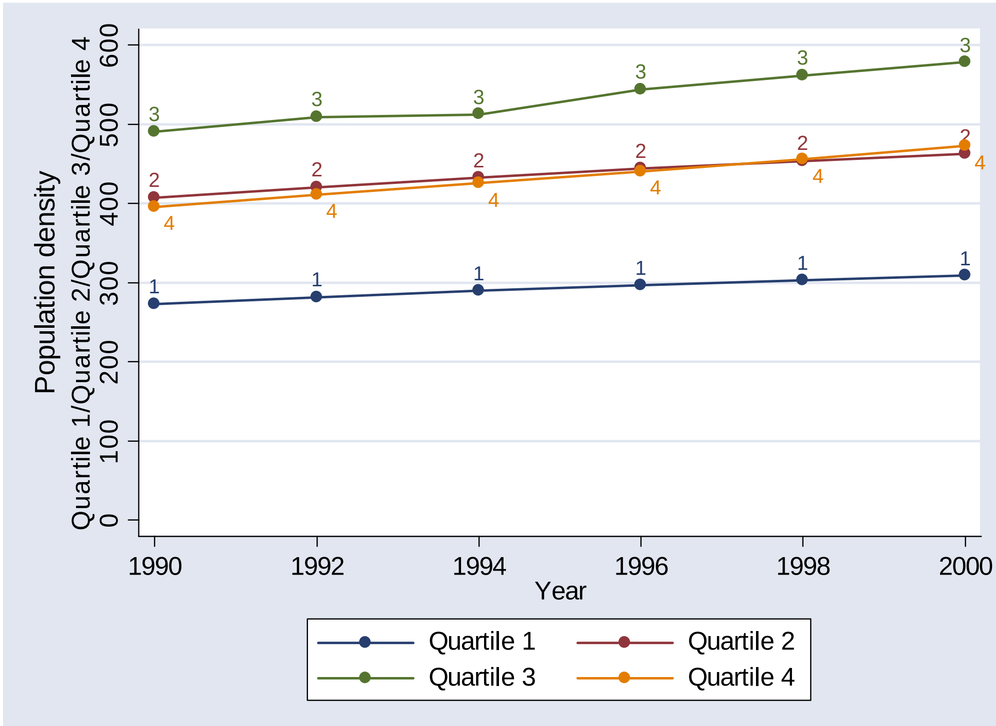
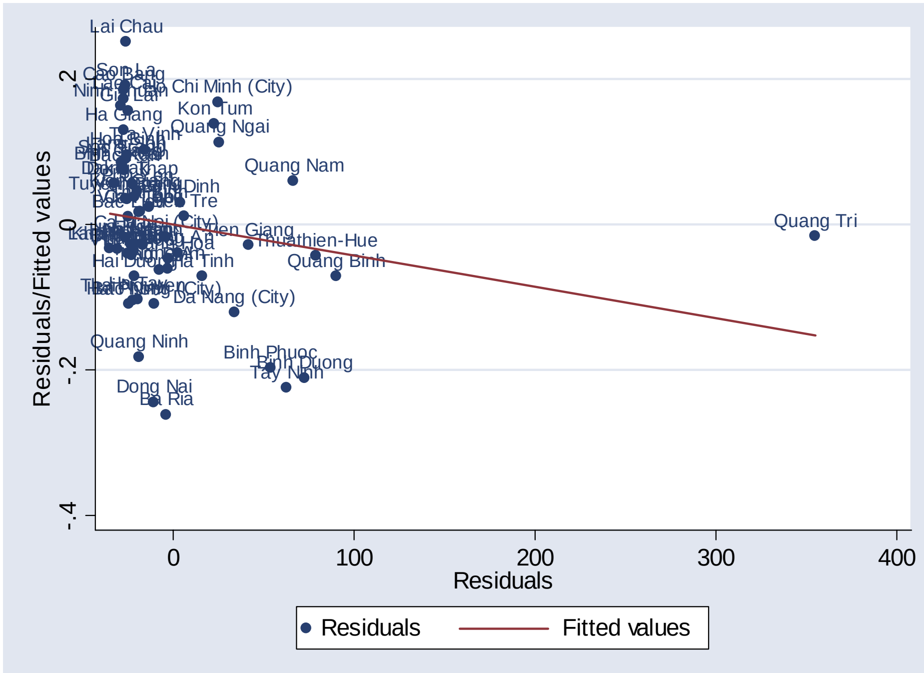


Figure 7: 1999 estimated province poverty rate vs.
Total U.S. bombs, missiles, and rocket intensity per km[2] in the province

(a) All Vietnam – conditional on 1960-61 province population density, South Vietnam indicator



(b) Central Region – conditional on 1960-61 province population density, South Vietnam indicator

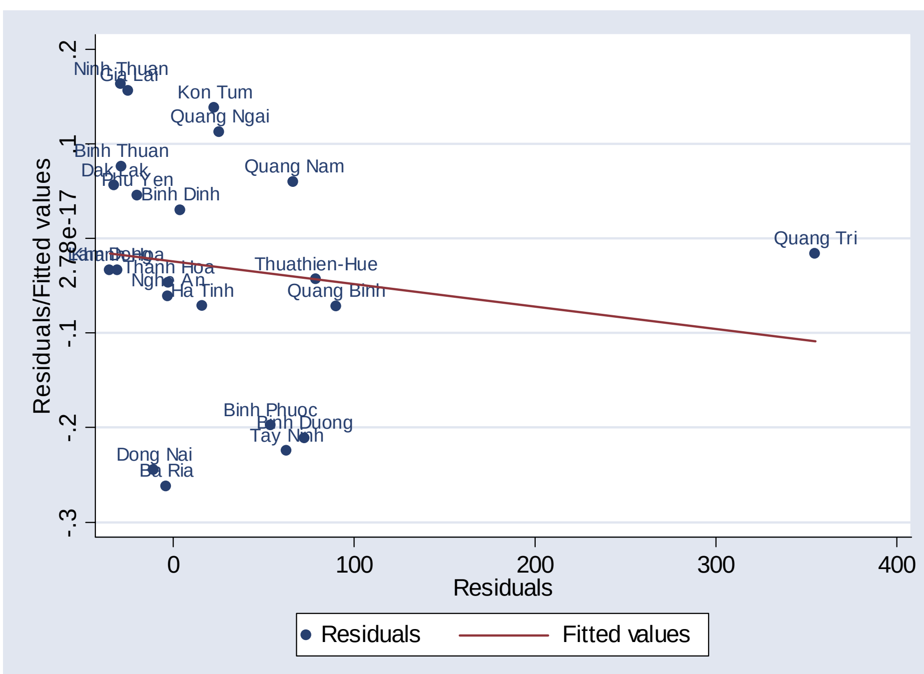
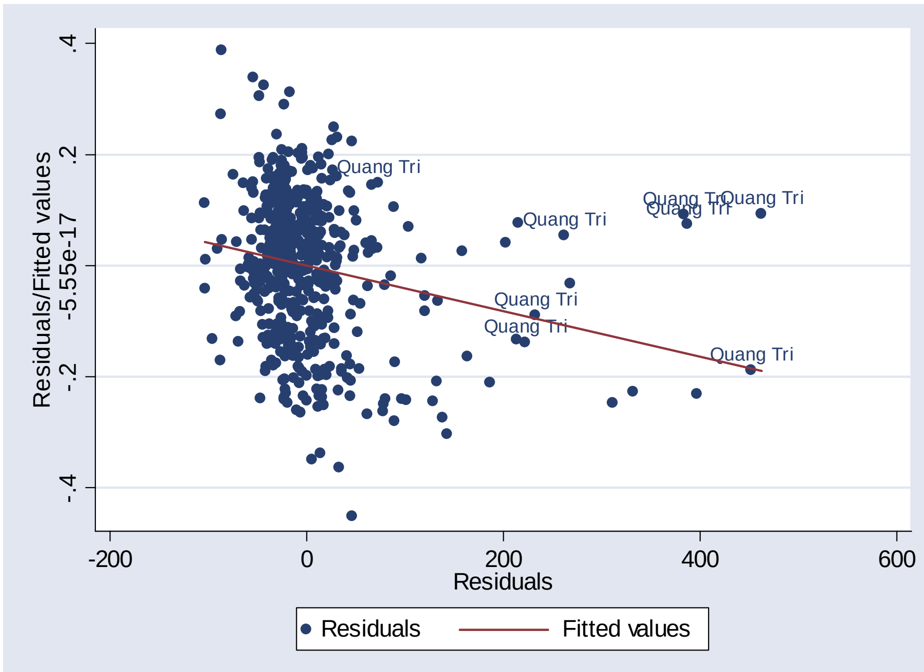


Figure 8: 1999 estimated district poverty rate vs.
Total U.S. bombs, missiles, and rocket intensity per km^2 in the district

(a) All Vietnam – conditional on 1960-61 province population density, South Vietnam indicator, district average temperature, average precipitation, elevation, and land area and area squared



(b) Central Region – conditional on 1960-61 province population density, South Vietnam indicator, district average temperature, average precipitation, elevation, land area and area squared, and soil types

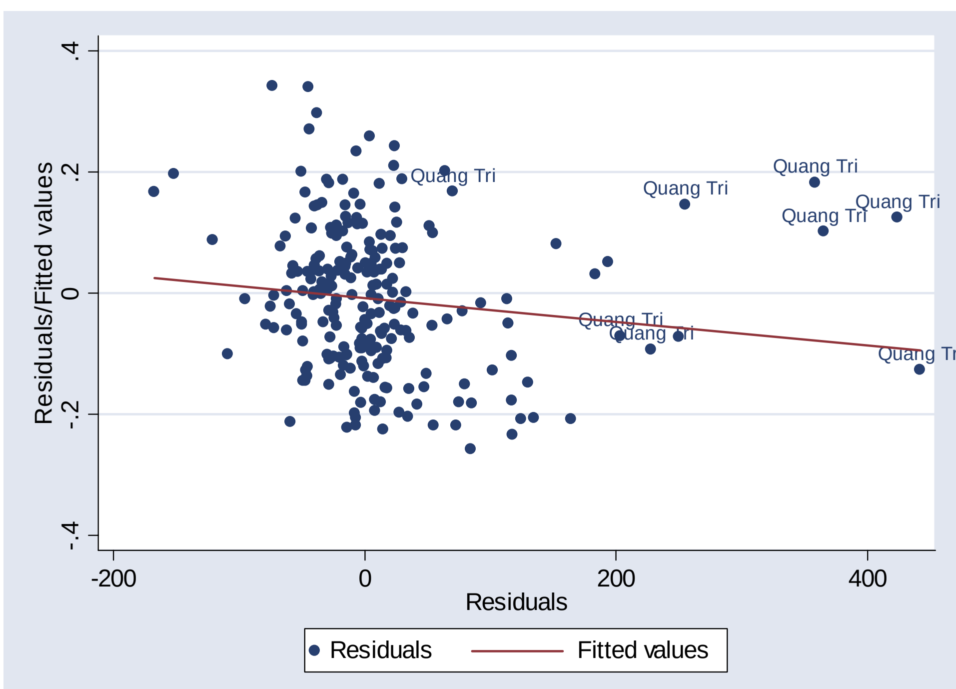


Table 1: U.S. ordnance data summary statistics

	All Vietnam					Central Region				
	Mean	S.D.	Min.	Max.	Obs.	Mean	S.D.	Min.	Max.	Obs.
Total U.S. bombs, missiles, and rockets intensity per km^2	32.3	68.4	0	561.5	585	56.7	91.0	0.234	561.5	229
Total U.S. bombs, missiles, and rockets	14667	37322	0	365449	585	32011	54645	31	365449	229
General purpose bombs	11105	30756	0	322111	585	24583	45580	31	322111	229
Cluster bombs	705	2266	0	32403	585	1433	3322	0	32403	229
Missiles	25	122	0	1600	585	49	191	0	1600	229
Rockets	2824	7202	0	106445	585	5927	10609	0	106445	229
Cannon artillery	8.5	51.8	0	772	585	19.5	80.4	0	772	229
Incendiaries	794	1642	0	11667	585	1545	2186	0	11667	229
White phosphorus	71	306	0	3580	585	165	466	0	3580	229
Land mines	94	353	0	4638	585	211	537	0	4638	229
Ammunition (000's of rounds)	5667	11054	0	136416	585	10244	14678	0	136416	229

Notes: The Central Region includes the following provinces: Ba Ria, Binh Dinh, Binh Duong, Binh Phuoc, Binh Thuan, Dak Lak, Dong Nai, Gia Lai, Ha Tinh, Khanh Hoa, Kon Tum, Lam Dong, Nghe An, Ninh Thuan, Phu Yen, Quang Binh, Quang Nam, Quang Ngai, Quang Tri, Tay Ninh, Thanh Hoa, and Thuathien-Hue, and excludes Da Nang (City) and Ho Chi Minh (City). The summary statistics are not weighted by population.

These samples exclude Quang Tri district (in Quang Tri province), which has by far the highest total U.S. bombs, missiles, and rockets intensity per km^2, at 3148. This outlier is excluded from the analysis.

Table 2: Estimated correlations among U.S. ordnance categories, by district

	General purpose bombs	Cluster bombs	Missiles	Rockets	Cannon artillery	Incendiaries	White phosphorus	Land mines
General purpose bombs	1							
Cluster bombs	0.59^{***}	1						
Missiles	0.27^{***}	0.18^{***}	1					
Rockets	0.64^{***}	0.56^{***}	0.34^{***}	1				
Cannon artillery	0.37^{***}	0.49^{***}	-0.00	0.11^{**}	1			
Incendiaries	0.65^{***}	0.58^{***}	0.09^{**}	0.40^{***}	0.43^{***}	1		
White phosphorus	0.27^{***}	0.22^{***}	0.08^{**}	0.39^{***}	0.13^{***}	0.24^{***}	1	
Land mines	0.43^{***}	0.33^{***}	0.30^{***}	0.67^{***}	0.00	0.04	0.26^{***}	1
Ammunition (000's of rounds)	0.54^{***}	0.58^{***}	0.06	0.32^{***}	0.60^{***}	0.82^{***}	0.18^{***}	-0.02

Notes: Estimated correlation coefficients. Significant at 90 (*), 95 (**), 99 (***) percent confidence. The results are for All Vietnam.

Table 3: Summary statistics – economic, demographic, climatic, and geographic data

	All Vietnam					Central Region				
	Mean	S.D.	Min.	Max.	Obs.	Mean	S.D.	Min.	Max.	Obs.
Panel A: Province level data										
Population density, 1960-61	213	322	9	1881	61	75	71	12	342	22
Population density, 1999	517	626	45	3797	61	259	136	58	502	22
Proportion not born in current village, 1997/98	0.26	0.24	0	1	56	0.32	0.30	0	1	21
Per capita consumption expenditures, 1992/93	1734	588	847	3487	56	1673	588	847	3417	21
Per capita consumption expenditures, 1997/98	2561	1064	1324	6335	56	2664	865	1559	4910	21
Growth in per capita consumption expenditures 1992/93-1997/98	0.76	0.47	0.01	2.26	56	0.92	0.47	0.04	2.26	21
Panel B: District level data										
Population density, 1999	1656	5841	10	52382	585	407	605	10	4098	229
Estimated district poverty rate, 1999	0.41	0.20	0.03	0.94	585	0.43	0.20	0.04	0.88	229
Proportion of households with access to electricity, 1999	0.71	0.27	0.08	1.00	585	0.67	0.26	0.10	1.00	229
Literacy rate, 1999	0.88	0.11	0.24	1.00	585	0.86	0.11	0.40	0.98	229
Proportion of land area 0-250m	0.75	0.37	0.00	1.00	585	0.64	0.39	0.00	1.00	229
Proportion of land area 250-500m	0.11	0.19	0.00	1.00	585	0.15	0.18	0.00	0.95	229
Proportion of land area 500-1000m	0.11	0.21	0.00	1.00	585	0.18	0.25	0.00	1.00	229
Proportion of land area over 1000m	0.03	0.11	0.00	1.00	585	0.04	0.13	0.00	1.00	229
Total district land area (km^2)	528.1	512.6	4	3230	585	741.6	550.1	10	2806	229
Average precipitation (cm)	154.6	30.1	84.2	282.0	585	167.4	38.5	84.2	282.0	229
Average temperature (celsius)	24.3	1.9	19.4	27.3	585	24.4	1.1	21.6	26.9	229
Former South Vietnam	0.49	0.50	0	1	585	0.65	0.48	0	1	229

Notes: The Central Region includes the following provinces: Ba Ria, Binh Dinh, Binh Duong, Binh Phuoc, Binh Thuan, Dak Lak, Dong Nai, Gia Lai, Ha Tinh, Khanh Hoa, Kon Tum, Lam Dong, Nghe An, Ninh Thuan, Phu Yen, Quang Binh, Quang Nam, Quang Ngai, Quang Tri, Tay Ninh, Thanh Hoa, and Thuathien-Hue, and excludes Da Nang (City) and Ho Chi Minh (City). The summary statistics are not weighted by population.

Table 4: Predicting bombing intensity

	Dependent variable: Total U.S. bombs, missiles, and rockets intensity per km^2					
	--------------------All Vietnam--------------------			--------------------Central Region--------------------		
	(1)	(2)	(3)	(4)	(5)	(6)
Population density, 1960-61	-0.005	-0.0035*	-0.0024**	0.110	-0.319	-0.163**
	(0.015)	(0.0020)	(0.0011)	(0.152)	(0.200)	(0.072)
Former South Vietnam	10.3	-50.7	-6.4	-71.6	-87.5	-15.4
	(15.0)	(42.0)	(17.3)	(57.1)	(64.1)	(17.8)
Proportion of land area 250-500m		-8.8	-25.0*		-39.4	-47.7
		(21.1)	(14.0)		(40.9)	(29.8)
Proportion of land area 500-1000m		14.4	-6.0		-7.4	-17.9
		(27.4)	(20.6)		(32.8)	(26.8)
Proportion of land area over 1000m		-6.2	-34.0		27.4	-25.5
		(42.5)	(25.4)		(63.6)	(30.4)
Total district land area (km^2)		-0.004	-0.009		-0.047	-0.012
		(0.021)	(0.019)		(0.055)	(0.040)
(Total district land area (km^2))^2 / 1000		0.000	0.003		0.013	0.004
		(0.007)	(0.006)		(0.017)	(0.013)
Average precipitation (cm)		0.77***	0.49***		0.78**	0.52***
		(0.28)	(0.10)		(0.30)	(0.11)
Average temperature (celsius)		14.5	3.0		26.8	11.0
		(11.3)	(5.1)		(16.3)	(7.8)
District soil type controls	No	No	No	No	Yes	Yes
Exclude Quang Tri province	No	No	Yes	No	No	Yes
Observations	61	585	577	22	229	221
R^2	0.01	0.08	0.11	0.18	0.37	0.35
Mean (s.d.) dependent variable	31.5 (55.9)	32.3 (68.4)	27.1 (50.6)	63.2 (81.5)	56.7 (91.0)	44.1 (58.5)

Notes: Robust Huber-White standard errors in parentheses. Significant at 90(*), 95(**), 99(***) percent confidence. Disturbance terms are clustered at the province level in regressions 2-3 and 5-6. The district soil type controls include the proportion of district land in 18 different soil categories. Soil controls are not included in regressions 2-3 since they are missing for most urban districts.

Table 5: Local war impacts on 1999 population density

	Dependent variable: Population density, 1999					
	All Vietnam			Central Region		
	(1)	(2)	(3)	(4)	(5)	(6)
Total U.S. bombs, missiles, and rockets intensity per km^2	-0.28	0.47	2.55	-0.49**	-0.25	0.20
	(0.27)	(7.53)	(12.19)	(0.19)	(0.50)	(1.05)
Population density, 1960-61	1.86***	0.40	0.40	0.95*	1.24***	1.26***
	(0.09)	(0.56)	(0.57)	(0.51)	(0.35)	(0.38)
Former South Vietnam	41.3	99.9	57.7	-53.2	23.1	21.8
	(46.7)	(808.9)	(673.4)	(57.9)	(120.8)	(122.8)
Proportion of land area 250-500m		2471	2513		117	100
		(2771)	(2674)		(182)	(201)
Proportion of land area 500-1000m		1423	1438		77	60
		(1868)	(1795)		(158)	(173)
Proportion of land area over 1000m		3204	3328		202	210
		(3609)	(3464)		(187)	(213)
Total district land area (km^2)		-9.9*	-9.9*		-1.33***	-1.33***
		(5.6)	(5.7)		(0.30)	(0.30)
(Total district land area (km^2))^2 / 1000		3.4*	3.4*		0.470***	0.472***
		(2.0)	(2.0)		(0.124)	(0.125)
Average precipitation (cm)		0.48	0.15		-1.08	-1.20
		(7.82)	(8.13)		(1.00)	(1.08)
Average temperature (celsius)		412.4	418.7		63.0	56.8
		(744.4)	(708.8)		(66.6)	(69.0)
District soil type controls	No	No	No	No	Yes	Yes
Exclude Quang Tri province	No	No	Yes	No	No	Yes
Observations	61	585	577	22	229	221
R^2	0.91	0.14	0.14	0.30	0.60	0.60
Mean (s.d.) dependent variable	517 (626)	1656 (5841)	1675 (5879)	259 (136)	407 (605)	413 (613)

Notes: Robust Huber-White standard errors in parentheses. Significant at 90(*), 95(**), 99(***) percent confidence. Disturbance terms are clustered at the province level in regressions 2-3 and 5-6. The district soil type controls include the proportion of district land in 18 different soil categories. Soil controls are not included in regressions 2-3 since they are missing for most urban districts.

Table 6: Local war impacts on estimated 1999 population density, alternative specifications

	Dependent variable: Population density, 1999							
	Ex-North Vietnam	Ex-South Vietnam	Rural: 1960-1 pop. density < 200 per km^2	Urban: 1960-1 pop. density ≥ 200 per km^2	All Vietnam	Central Region	All Vietnam	Central Region
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Total U.S. bombs, missiles, and rockets intensity per km^2	10.70	-16.53	-0.45	-5.34	7.35	-0.39		
	(7.73)	(11.06)	(0.73)	(18.99)	(11.55)	(1.01)		
Top 10% of districts, total U.S. bombs, missiles, and rockets intensity per km^2							14.56	-32.60
							(400.44)	(60.92)
Population density, 1960-61	7.39***	0.00	0.07	-0.67			0.40	1.28***
	(2.02)	(0.41)	(1.02)	(0.61)			(0.55)	(0.31)
Former South Vietnam			231.8	-29814			77.7	39.1
			(205.3)	(18135)			(591.8)	(103.1)
District geographic, climatic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province fixed effects	No	No	No	No	Yes	Yes	No	No
District soil type controls	No	No	No	No	No	Yes	No	Yes
Observations	301	284	409	176	585	229	585	229
R^2	0.37	0.19	0.23	0.43	0.48	0.62	0.14	0.59
Mean (s.d.) dependent variable	1348 (4069)	1982 (7256)	451 (976)	4457(10018)	1656 (5841)	407 (605)	1656 (5841)	407 (605)

Notes: Robust Huber-White standard errors in parentheses. Significant at 90(*), 95(**), 99(***) percent confidence. Disturbance terms are clustered at the province level. District geographic and climatic controls include Proportion of land area 250-500m, Proportion of land area 500-1000m, Proportion of land area over 1000m, Total district land area (km^2), (Total district land area (km^2))^2 / 1000, Average precipitation (cm), Average temperature (celsius). The district soil type controls include the proportion of district land in 18 different soil categories. Soil controls are not included in regressions 5 and 7 since they are missing for most urban districts.

Table 7: Local war impacts on population characteristics

	All Vietnam		Central Region	
	(1)	(2)	(3)	(4)
Panel A: Dependent variable: Growth in population density, 1990 to 2000				
Total U.S. bombs, missiles, and rockets intensity per km^2	0.015	-0.059	-0.027	-0.126*
	(0.047)	(0.114)	(0.031)	(0.070)
Population density, 1960-61	0.30***	0.30***	0.12***	0.14***
	(0.05)	(0.05)	(0.04)	(0.04)
Former South Vietnam	18.3	20.3*	16.0*	16.1*
	(11.6)	(11.2)	(8.0)	(8.0)
Exclude Quang Tri province	No	Yes	No	Yes
Observations	61	60	22	21
R^2	0.79	0.79	0.22	0.23
Mean (s.d.) dependent variable	64.3 (107.8)	65.0 (108.6)	38.2 (24.6)	38.9 (24.9)
Panel B: Dependent variable: 1997/98 proportion not born in current village				
Total U.S. bombs, missiles, and rockets intensity per km^2	-0.00030	-0.00008	-0.00029	-0.00025
	(0.00025)	(0.00072)	(0.00030)	(0.00120)
Population density, 1960-61	0.00011	0.00011	-0.00061	-0.00062
	(0.00009)	(0.00009)	(0.00054)	(0.00054)
Former South Vietnam	0.20***	0.19***	0.34***	0.34***
	(0.06)	(0.06)	(0.08)	(0.08)
Exclude Quang Tri province	No	Yes	No	Yes
Observations	56	55	21	20
R^2	0.19	0.17	0.34	0.30
Mean (s.d.) dependent variable	0.26 (0.24)	0.26 (0.24)	0.32 (0.30)	0.34 (0.30)
Panel C: Dependent variable: 1997/98 proportion household heads in Veterans Association				
Total U.S. bombs, missiles, and rockets intensity per km^2	0.00024**	0.00015	0.00023***	0.00023
	(0.00010)	(0.00034)	(0.000076)	(0.00041)
Population density, 1960-61	-0.000018	-0.000017	-0.00022*	-0.00022
	(0.000015)	(0.000016)	(0.00012)	(0.00018)
Former South Vietnam	-0.12***	-0.12***	-0.14***	-0.14***
	(0.01)	(0.02)	(0.03)	(0.03)
Exclude Quang Tri province	No	Yes	No	Yes
Observations	56	55	21	20
R^2	0.60	0.57	0.75	0.68
Mean (s.d.) dependent variable	0.075 (0.077)	0.072 (0.075)	0.059 (0.086)	0.050 (0.077)

Notes: Robust Huber-White standard errors in parentheses. Significant at 90(*), 95(**), 99(***) percent confidence.

Table 8: Local war impacts on estimated 1999 poverty rate

	Dependent variable: Estimated poverty rate, 1999					
	--------------------All Vietnam--------------------			----------------Central Region----------------		
	(1)	(2)	(3)	(4)	(5)	(6)
Total U.S. bombs, missiles, and rockets	-0.00043	-0.00041**	-0.00072***	-0.00015	-0.00018	-0.00067**
intensity per km^2	(0.00031)	(0.00019)	(0.00016)	(0.00024)	(0.00020)	(0.00027)
Population density, 1960-61	-0.00026***	-0.000019**	-0.000019**	-0.00078***	0.00009	0.00007
	(0.00006)	(0.000007)	(0.000007)	(0.00026)	(0.00018)	(0.00018)
Former South Vietnam	-0.16***	-0.18***	-0.17***	-0.16***	-0.08**	-0.06
	(0.03)	(0.05)	(0.05)	(0.05)	(0.04)	(0.04)
Proportion of land area 250-500m		0.16***	0.15***		0.23**	0.20*
		(0.05)	(0.05)		(0.10)	(0.10)
Proportion of land area 500-1000m		0.15**	0.14**		0.12*	0.11
		(0.06)	(0.06)		(0.07)	(0.07)
Proportion of land area over 1000m		0.30***	0.28**		-0.26***	-0.30***
		(0.11)	(0.11)		(0.06)	(0.07)
Total district land area (km^2)		0.00035***	0.00034***		0.00018**	0.00017**
		(0.00006)	(0.00006)		(0.00006)	(0.00007)
(Total district land area (km^2))^2 / 1000		-0.000099***	-0.000095***		-0.000050*	-0.000045
		(0.000024)	(0.000024)		(0.000025)	(0.000027)
Average precipitation (cm)		0.00081*	0.00084*		0.00099**	0.00111**
		(0.00045)	(0.00045)		(0.00046)	(0.00046)
Average temperature (celsius)		0.017	0.013		-0.057***	-0.061***
		(0.013)	(0.014)		(0.018)	(0.018)
District soil type controls	No	No	No	No	Yes	Yes
Exclude Quang Tri province	No	No	Yes	No	No	Yes
Observations	61	585	577	22	229	221
R^2	0.53	0.64	0.65	0.32	0.72	0.75
Mean (s.d.) dependent variable	0.41 (0.16)	0.41 (0.20)	0.41 (0.20)	0.37 (0.15)	0.43 (0.20)	0.43 (0.20)

Notes: Robust Huber-White standard errors in parentheses. Significant at 90(*), 95(**), 99(***) percent confidence. Disturbance terms are clustered at the province level in regressions 2-3 and 5-6. The district soil type controls include the proportion of district land in 18 different soil categories. Soil controls are not included in regressions 2-3 since they are missing for most urban districts.

Table 9: Local war impacts on estimated 1999 poverty rate, alternative specifications

	Dependent variable: Estimated poverty rate, 1999							
	Ex-North Vietnam	Ex-South Vietnam	Rural: 1960-1 pop. density < 200 per km^2	Urban: 1960-1 pop. density ≥ 200 per km^2	All Vietnam	Central Region	All Vietnam	Central Region
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Total U.S. bombs, missiles, and rockets intensity per km^2	-0.00031 (0.00019)	-0.00067 (0.00041)	-0.00021 (0.00021)	-0.00047*** (0.00010)	-0.00050*** (0.00010)	-0.00033** (0.00013)		
Top 10% of districts, total U.S. bombs, missiles, and rockets intensity per km^2							-0.114*** (0.034)	-0.065** (0.025)
Population density, 1960-61	-0.00012*** (0.00003)	-0.000016*** (0.000004)	0.00081*** (0.00020)	-0.000010* (0.000005)			-0.000018*** (0.000007)	0.00007 (0.00019)
Former South Vietnam			-0.14*** (0.04)	-0.26 (0.17)			-0.18*** (0.04)	-0.08* (0.04)
District geographic, climatic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province fixed effects	No	No	No	No	Yes	Yes	No	No
District soil type controls	No	No	No	No	No	Yes	No	Yes
Observations	301	284	409	176	585	229	585	229
R^2	0.76	0.49	0.62	0.78	0.82	0.83	0.64	0.73
Mean (s.d.) dependent variable	0.46 (0.20)	0.35 (0.18)	0.46 (0.19)	0.29 (0.16)	0.41 (0.20)	0.43 (0.20)	0.41 (0.20)	0.43 (0.20)

Notes: Robust Huber-White standard errors in parentheses. Significant at 90(*), 95(**), 99(***) percent confidence. Disturbance terms are clustered at the province level. District geographic and climatic controls include Proportion of land area 250-500m, Proportion of land area 500-1000m, Proportion of land area over 1000m, Total district land area (km^2), (Total district land area (km^2))^2 / 1000, Average precipitation (cm), Average temperature (celsius). The district soil type controls include the proportion of district land in 18 different soil categories. Soil controls are not included in regressions 5 and 7 since they are missing for most urban districts.

Table 10: Local war impacts on consumption expenditures and growth (VLSS data)

	----------All Vietnam----------		----------Central Region----------	
	(1)	(2)	(3)	(4)
Panel A: Dependent variable: 1997/98 per capita consumption expenditures				
Total U.S. bombs, missiles, and rockets intensity per km^2	1.65	6.87**	0.16	5.65
	(1.77)	(2.93)	(1.65)	(4.75)
Population density, 1960-61	1.95***	1.89***	1.11	-0.26
	(0.45)	(0.45)	(1.48)	(1.68)
Former South Vietnam	920***	783***	969***	975***
	(194)	(199)	(242)	(250)
Exclude Quang Tri province	No	Yes	No	Yes
Observations	56	55	21	20
R^2	0.49	0.52	0.27	0.27
Mean (s.d.) dependent variable	2561 (1064)	2579 (1065)	2664 (865)	2719 (849)
Panel B: Dependent variable: 1992/93 per capita consumption expenditures				
Total U.S. bombs, missiles, and rockets intensity per km^2	-1.22**	-1.33	-0.92	-0.06
	(0.48)	(1.49)	(0.65)	(2.60)
Population density, 1960-61	0.70***	0.70***	-0.27	-0.49
	(0.17)	(0.17)	(0.76)	(0.65)
Former South Vietnam	679***	682***	658***	659***
	(113)	(128)	(129)	(128)
Exclude Quang Tri province	No	Yes	No	Yes
Observations	56	55	21	20
R^2	0.45	0.42	0.35	0.27
Mean (s.d.) dependent variable	1734 (588)	1750 (581)	1673 (588)	1714 (571)
Panel C: Dependent variable: Growth in consumption, 1992/93- 1997/98				
Total U.S. bombs, missiles, and rockets intensity per km^2	0.0020**	0.0043***	0.0008	0.0018
	(0.0008)	(0.0014)	(0.0007)	(0.0022)
Population density, 1960-61	0.00042**	0.00040**	0.00075	0.00052
	(0.00017)	(0.00017)	(0.00089)	(0.00081)
Former South Vietnam	0.04	-0.02	0.05	0.05
	(0.12)	(0.12)	(0.17)	(0.17)
Exclude Quang Tri province	No	Yes	No	Yes
Observations	56	55	21	20
R^2	0.14	0.17	0.03	0.04
Mean (s.d.) dependent variable	0.76 (0.47)	0.75 (0.47)	0.92 (0.47)	0.91 (0.48)

Notes: Robust Huber-White standard errors in parentheses. Significant at 90(*), 95(**), 99(***) percent confidence.

Table 11: Local war impacts on 1999 proportion of households with access to electricity

	Dependent variable: Proportion of households with access to electricity, 1999					
	All Vietnam			Central Region		
	(1)	(2)	(3)	(4)	(5)	(6)
Total U.S. bombs, missiles, and rockets	0.00056*	0.00044***	0.00056***	-0.00027	0.00018	0.00028
intensity per km^2	(0.00032)	(0.00014)	(0.00021)	(0.00028)	(0.00015)	(0.00029)
Population density, 1960-61	0.000311***	0.000020***	0.000020***	0.00082**	-0.000044	-0.000036
	(0.000071)	(0.000005)	(0.000005)	(0.00031)	(0.000199)	(0.000197)
Former South Vietnam	-0.13***	0.04	0.03	-0.14***	-0.05	-0.07
	(0.05)	(0.05)	(0.06)	(0.05)	(0.05)	(0.05)
District geographic, climatic controls	No	Yes	Yes	No	Yes	Yes
District soil type controls	No	No	No	No	Yes	Yes
Exclude Quang Tri province	No	No	Yes	No	No	Yes
Observations	61	585	577	22	229	221
R^2	0.35	0.59	0.59	0.34	0.67	0.67
Mean (s.d.) dependent variable	0.71 (0.21)	0.71 (0.27)	0.71 (0.27)	0.73 (0.14)	0.67 (0.26)	0.66 (0.26)

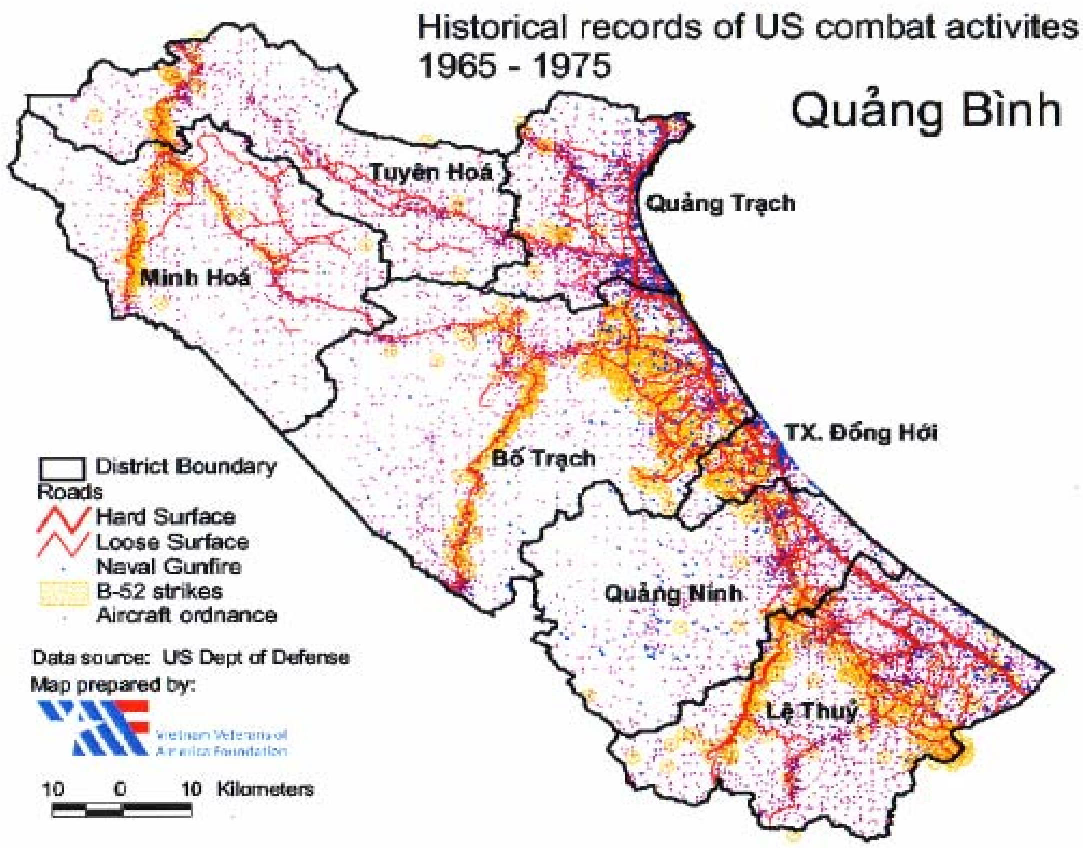
Notes: Robust Huber-White standard errors in parentheses. Significant at 90(*), 95(**), 99(***) percent confidence. Disturbance terms are clustered at the province level in regressions 2-3 and 5-6. District geographic and climatic controls include Proportion of land area 250-500m, Proportion of land area 500-1000m, Proportion of land area over 1000m, Total district land area (km^2), (Total district land area (km^2))^2 / 1000, Average precipitation (cm), Average temperature (celsius). The district soil type controls include the proportion of district land in 18 different soil categories. Soil controls are not included in regressions 2-3 since they are missing for most urban districts.

Table 12: Local war impacts on 1999 literacy rate (among survey respondents)

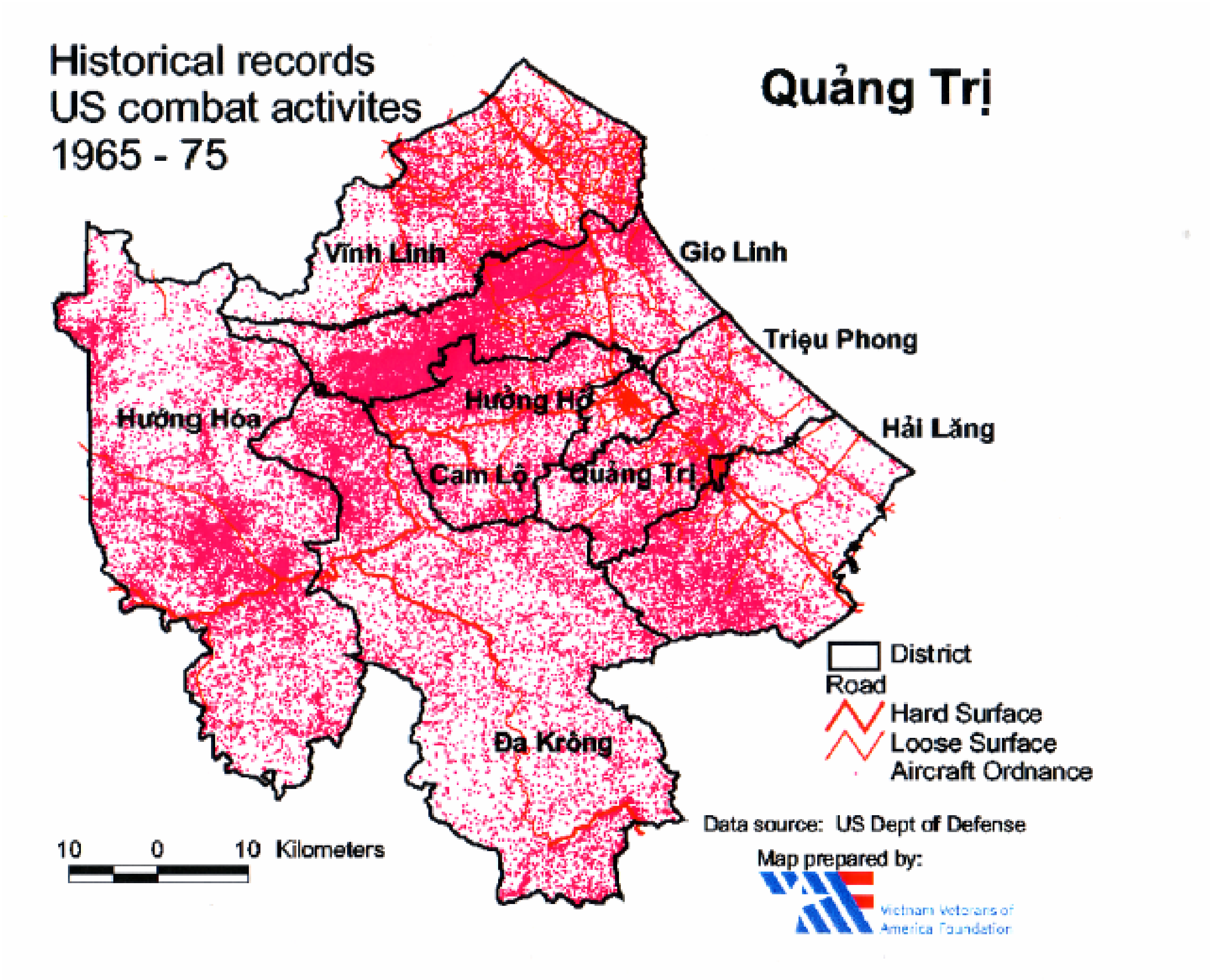
	Dependent variable: Proportion of literate respondents, 1999					
	-----------------All Vietnam-----------------			-----------------Central Region-----------------		
	(1)	(2)	(3)	(4)	(5)	(6)
Total U.S. bombs, missiles, and rockets	0.00011	0.00005	0.00011*	-0.00012*	-0.00003	0.00003
intensity per km^2	(0.00011)	(0.00006)	(0.0006)	(0.00006)	(0.00008)	(0.00012)
Population density, 1960-61	0.000100***	0.000021	0.000022*	0.00026**	-0.00009	-0.00009
	(0.000037)	(0.000013)	(0.00013)	(0.00009)	(0.00011)	(0.00011)
Former South Vietnam	0.008	0.024	0.015	-0.036*	0.012	0.000
	(0.020)	(0.036)	(0.037)	(0.020)	(0.027)	(0.026)
District geographic, climatic controls	No	Yes	Yes	No	Yes	Yes
District soil type controls	No	No	No	No	Yes	Yes
Exclude Quang Tri province	No	No	Yes	No	No	Yes
Observations	61	585	577	22	229	221
R^2	0.16	0.54	0.54	0.18	0.55	0.55
Mean (s.d.) dependent variable	0.88	0.88	0.88	0.88	0.86 (0.11)	0.86
	(0.08)	(0.11)	(0.11)	(0.06)		(0.11)

Notes: Robust Huber-White standard errors in parentheses. Significant at 90(*), 95(**), 99(***) percent confidence. Disturbance terms are clustered at the province level in regressions 2-3 and 5-6. District geographic and climatic controls include Proportion of land area 250-500m, Proportion of land area 500-1000m, Proportion of land area over 1000m, Total district land area (km^2), (Total district land area (km^2))^2 / 1000, Average precipitation (cm), Average temperature (celsius). The district soil type controls include the proportion of district land in 18 different soil categories. Soil controls are not included in regressions 2-3 since they are missing for most urban districts.

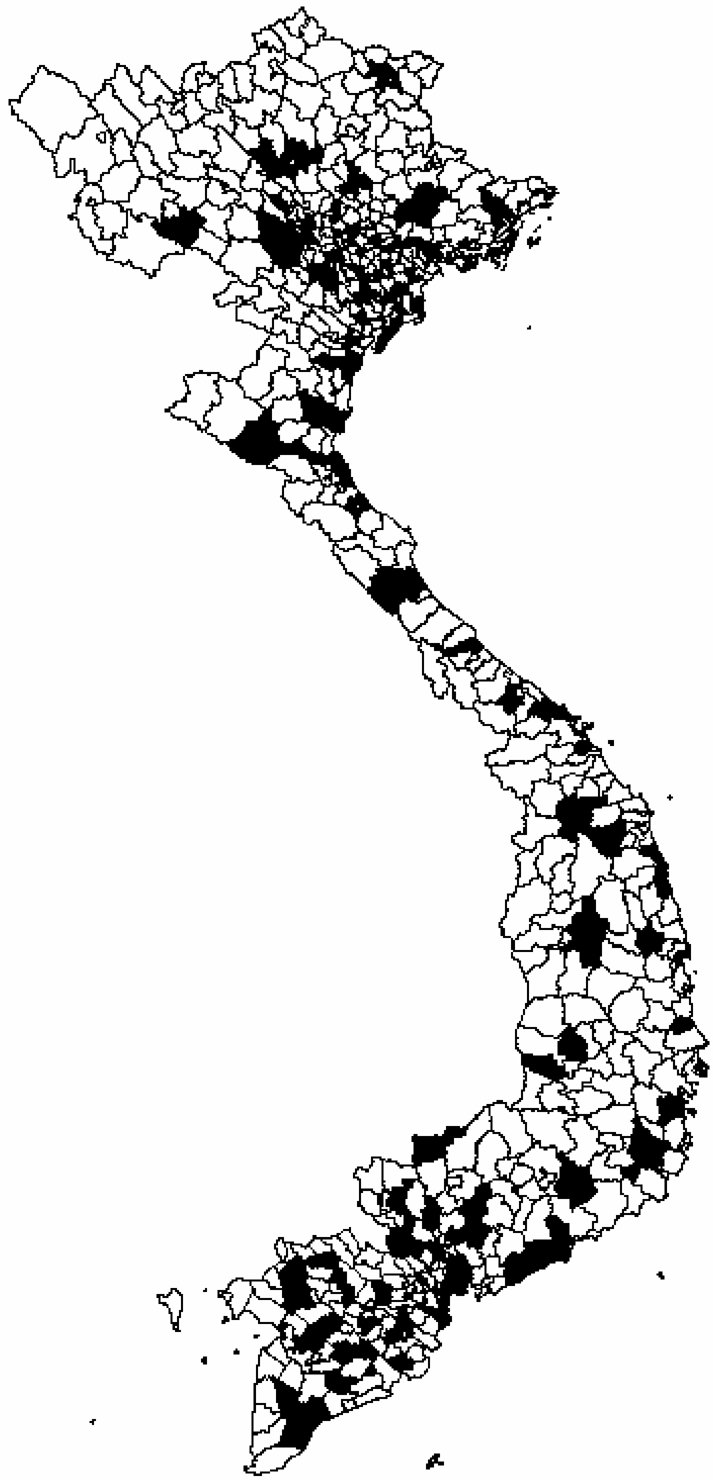
Appendix Figure 1: Raw DSCA bombing data, Quang Binh province



Appendix Figure 2: Raw DSCA bombing data, Quang Tri province



Appendix Figure 3: Map of Vietnam – districts with VLSS data (shaded)



Data Appendix

(1) U.S. Military data

The bombing data in this paper are derived from the following files, housed at the National Archives in Record Group 218, "Records of the U.S. Joint Chiefs of Staff":

Combat Activities File (CACTA)

- October 1965 – December 1970; November 1967 not available. Monthly. Derived from Combat Activities Reports II/III (COACT II/III), detailing daily air combat operations flown by the US Navy, Marine Corps, and Pacific Air Forces. Carter et al. (1976) list data cards for Army and USMC helicopters as primary input sources.

Southeast Asia Database (SEADAB)

- January 1970 – June 1975. Daily records of friendly air combat activities flown by the US Army, Navy, Air Force, and Marine Corps, as well as the (South) Vietnamese Air Force, Royal Lao Air Force, and Khmer (Cambodian) Air Force. Includes both fixed-wing aircraft and helicopters.

Combat Naval Gunfire File (CONGA)

- March 1966 – January 1973. Records of naval gunfire support in North and South Vietnam.

To the best of our knowledge, these data cover all air combat operations flown by all allied forces involved in the Second Indochina War, including Thai and Australian. Some of the original tape archives were damaged, so several months of data may be missing.

The data are geocoded at the district level, employing the codes and boundaries used by the General Statistical Office in the 1999 Population and Housing census. The air ordnance data are divided into 16 categories by type: ammunition, cannon artillery, chemical, cluster bomb, flare, fuel air explosive, general purpose (iron bomb), grenade, incendiary, mine, missile, other, rocket, submunition, torpedo, and unknown. All entries denote number of units, rather than weight, of ordnance expended by district. Nearly all entries denote single units; most ammunition-class entries denote hundreds of units. The naval gunfire data are divided into approximately forty specific categories.

Type of ordnance, quantity of ordnance, and drop location were originally recorded by the pilots and gunners who fired the weapons. Such records were created every time ordnance was expended. The data were reported to Pacific Command and ultimately the Joint Chiefs, who declassified the CACTA, SEADAB, CONGA files in 1975, after which they were sent to the National Archives.

The data were provided by Tom Smith at the Defense Security Cooperation Agency (DSCA), in cooperation with Michael Sheinkman of the Vietnam Veterans of America Foundation (VVAF). We are indebted to Tom Smith, Michael Sheinkman, and Bill Shaw A01 (AW) USN (ret.) for their assistance in understanding the data. VVAF sought and obtained permission from BOMICO [Technology Center for Bomb and Mine Disposal, a department of the Engineering Command of the Vietnam Ministry of Defense] to provide the data to us.

Clodfelter (1995: 216-7) summarizes U.S. ordnance: "Most bombs dropped by U.S. aircraft were either 750-pounders (favored by the U.S. Air Force) or 500-pounders (favored by the U.S. Navy), but bombs of up to 2,000 pounds and other ordnance of unconventional design and purpose were employed. Included among America's air arsenal were antipersonnel bombs whose outer casing opened to release a string of small warheads along a line of one hundred yards. Some of the other U.S. antipersonnel and high-explosive bombs were the Lazy Dog, which exploded thirty yards above the ground to release a steel sleet of hundreds of tiny darts; cluster bombs, which were ejected from large canisters by small explosive charges after they had penetrated the upper canopy of the forest; and Snake Eyes, which oscillated earthward under an umbrellalike apparatus that retarded the rate of fall long enough to allow the bombing aircraft to come in low with its bomb load and then escape the resulting effects of the detonation." The following table provides more details.

Appendix Table 1: U.S. Ordnance Categories

Ordnance category	Description
General purpose bombs	Conventional iron bombs, free-falling and unguided. "These account for the greatest fraction of the total weight of aerial munitions used; they are carried by fighter-bombers, attack bombers, and high-flying strategic bombers (B-52s), and delivered by free fall. ... Weight ranges from 100 pounds to 3000 pounds; most common range is 500-1000 pounds; about 50 percent of weight is explosive. The bomb works mostly by blast effect, although shrapnel from the casing is also important. ... The crater from a 500-lb. bomb with impact fuze (e.g., MK 82) is typically 30 feet in diameter and 15 feet deep (this obviously varies greatly with the terrain). Shrapnel is important over a zone about 200 feet in diameter. Simple shelters (sandbags, earthworks, even bamboo) protect against all but close hits." (Littauer et al 1972: 222). "The biggest of [the GP bombs] was the 15,000-pound BLU-82B 'Daisy Cutter'." (Doleman 1984: 127)
Cluster bombs	Cluster bomb units (CBUs) scatter the submunitions they contain—ranging from under forty to over 600 in number—over a wide area, yielding a much broader destruction radius than conventional iron bombs. The outer casing is "blown open (by compressed gas) above ground level (typically 500-foot altitude), distributing bomblets over an area several hundred feet on a side." (Littauer et al 1972: 222). In our dataset primarily fragmentary general purpose, anti-personnel, and anti-material weapons, and occasionally tear gas or smoke, ranging in total bomb weight from 150 to over 800 lbs.
Missiles	Self-guided air-deployed munitions. Includes self-propelled air-to-air and air-to-ground missiles (typically hone in on radiation from engines or radar) as well as free-fall "smart bombs" (guided toward their targets by laser reflection or electro-optical imaging, e.g., AGM-62 "Walleye.") "The most important anti-radiation air-to-ground missiles used by the U.S. forces in Vietnam were the AGM-45 Shrike and AGM-78 Standard ARM. Radar-directed like the Sparrow, the Shrike was carried by navy and air force jets, including the Wild Weasels. Its purpose was to knock out the ground radar stations that controlled the deadly SAMs and radar-guided anti-aircraft guns." (Doleman 1984: 125).

Rockets	Self-propelled unguided munitions. “The most common size is 2.75" diameter, delivered singly or in bursts from tubes mounted under the aircraft. Accuracy of delivery is generally higher than for free-fall weapons. Warheads include fragmentation (flechette), high explosive (including shaped charge against armored vehicles), and incendiary action (most white phosphorus or plasticized white phosphorus, PWP). Phosphorus may be used as anti-personnel weapon, but also serves to generate white smoke (often for target designation for further strikes).” (Littauer et al 1972: 223)
Cannon artillery	High-velocity projectiles too large to be labeled ‘Ammunition’. Chiefly, high explosive rounds from 105mm Howitzers. (Sources: personal communication with Bill Shaw, 4/16/04)
Incendiaries / white phosphorus	Napalm fire bombs and white phosphorus smoke bombs (<5%). Total fire bomb weights range from 250lb to 750lb, containing between 33-100 gallons of combustible napalm gel. Napalm was primarily successful as a wide-area anti-personnel weapon: “Most effective against entrenched infantry, napalm gave off no lethal fragments and could be used close to friendly forces without the dangers of fragmentation posed by conventional bombs. Often the fire from napalm would penetrate jungle that was immune to shrapnel. A single napalm canister spread its contents over an area a hundred yards long.” (Doleman 1984: 127)
Land mines	Primarily air-dropped ‘Destructor’ mines. “Destructor Mines are general purpose low-drag [GP] bombs converted to mines. They can be deployed by air, either at sea as bottom mines or on land as land mines. … When dropped on land, they bury themselves in the ground on impact, ready to be actuated by military equipment, motor vehicles and personnel. When dropped in rivers, canals, channels, and harbors, they lie on the bottom ready to be actuated by a variety of vessels including war ships, freighters, coastal ships, and small craft.” (Fas 2004) With just over 55,000 mines listed for the entire country in our dataset, compared with an outside estimate of 3,500,000 mines (UNMAS 2004), our data capture a trivial fraction of total presumed landmine presence in Vietnam, likely because a large share of landmines were placed in the ground by U.S. combatants on foot.
Ammunition (000’s of rounds)	Projectiles fired from air at high-velocity. Cross-sectional diameter (caliber) ranges from 5.56mm to 40mm, spanning the traditional categories of small-arms (≤0.50 caliber/inches = 12.7mm), regular ammunition, and cannon artillery (≥20mm). (Sources: FAS (2004); personal communication with Bill Shaw, 4/16/04)

(2) Vietnam Poverty, Geographic, and Climatic Data

District-level estimates of poverty were provided by Nicholas Minot of the International Food Policy Research Institute (IFPRI). The estimates were generated through poverty mapping, one application of the small-area estimation method (Elbers et al 2003). This method matches detailed, small-sample survey data to less-detailed, large-sample census data across geographic units, to generate area-level estimates of an individual- or household-level phenomenon—in our case, district-level poverty incidence in Vietnam. For more detailed information, see Minot et al. (2003).

The two datasets used by Minot et al. (2003) are the 1997/8 Vietnam Living Standards Survey (VLSS) and a 33% subsample (5,553,811 households) of the 1999 Population and Housing Census. The VLSS, undertaken by the Vietnam General Statistical Office (GSO) in Hanoi, with technical assistance from the World Bank, is a detailed, household-level survey of 4270 rural and 1730 urban Vietnamese households. The Population and Housing Census was conducted by the GSO with technical support from the United Nations Family Planning Agency and United Nations Development Program (UNDP). We also use data from the 1992/3 VLSS.

Minot et al. use the VLSS data to estimate a household-level, log-linear regression of real, cost-of-living-adjusted, per capita consumption expenditure on 17 household characteristics common to both the VLSS and the Population and Housing Census. These include: household size, proportion over 60 years old, proportion under 15 years old, proportion female, highest level of education completed by head of household, whether or not head has a spouse, highest level of education completed by spouse, whether or not head is an ethnic minority, occupation of head over last 12 months, type of house (permanent; semi-permanent or wooden frame, "simple), house type interacted with living area, whether or not household has electricity, main source of drinking water, type of toilet, whether or not household owns a television, whether or not household owns a radio, region. Minot et al. (2003) partition the sample to undertake separate parameter estimates for the correlates of rural and urban poverty.

Predicted consumption expenditures per capita for each of the district-coded households in the Population and Housing Census sample are then generated using the parameter estimates from these regressions. Properly weighting by the size of each household, this enables them to generate an estimate of district-level poverty incidence, the percentage of the population in each district that lives below the "overall poverty line" of 1,789,871 Vietnam dong (VND) per person per year (GSO 2000).

All district-level topographic, geographic, and climatic data used in this paper were provided by Nicholas Minot and are identical to those used in Minot et al. (2003). The topographical data used in Minot et al. (2003) are taken from the United States Geological survey. Province population figures in the 1990s are from the Vietnam Statistical Yearbooks.

(3) Data from the pre-"American War" period

Pre-war, province-level demographic data on South Vietnam were taken from the 1959-1965 editions of the *Statistical Yearbook of Vietnam*, published by the National Institute of Statistics in Saigon, and for North Vietnam from the *Vietnam Agricultural Statistics over 35 Years (1956-1990)*, published by the GSO Statistical Publishing House in Hanoi (1991). Province level agricultural statistics are also available (e.g., rice paddy yields), but it is widely thought that such prewar data are unreliable as a result of the prewar ideological conflict between North and South Vietnam (Banens 1999), and thus we do not use these data in the analysis.