The Long Run Impact of Bombing Vietnam[♦]

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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, and had massive humanitarian costs. We use a unique U.S. military dataset containing bombing intensity at the district level (N=584). 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 robust statistically significant negative impact on poverty rates, consumption levels, infrastructure, literacy or population density through 2002. This finding suggests that recovery from war damage can be rapid under certain conditions, although further work is needed to establish the generality of the finding in other settings.

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1. Introduction

The horrors inflicted by war are clear to all, and so are its disruptive effects for people's lives. Indeed, war displaces population, destroys capital and infrastructure, 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 later 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 regarding the effect of war on long-run economic performance. To the extent that the main impact of war is the destruction of existing physical capital and reduced 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 impact. However, war may also profoundly affect the quality of institutions, technology, and social outcomes. The institutional effects of war may in turn have effects on long-run economic performance that could be negative or positive. For instance, it is often argued that military research and development lead to faster technological progress, which may offset war damage. Wars may also promote state formation and nation building as was the case in Europe (Tilly 1975), and may induce social progress via greater popular participation. For instance, political enfranchisement historically has often been a byproduct of war (Keyssar 2000). This social and political progress may in turn enhance public goods provision. The net long run effects of war are thus unclear a priori from the point of view of theory.

The long run economic impacts of war remain largely unexplored empirically, and this is so for several reasons. One important issue is the difficulty of convincingly identifying war impacts on economic growth in the presence of dual causality between violence and economic conditions, and possible omitted variable biases (see Miguel et al 2004 for a related discussion). But a perhaps even more fundamental constraint for empirical work is the lack of data on war damage and economic conditions in conflict (and post-conflict) societies.

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 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 at least 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.

For another comparison, the atomic bombs dropped at Hiroshima and Nagasaki had the power of roughly 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, each atomic bomb translates into roughly 30,000 to 40,000 tons of such munitions. Measured this way, U.S. bombing in Indochina represents 100 times the combined impact of the Hiroshima and Nagasaki atomic bombs. Given the unprecedented intensity of U.S. bombing, subsequent economic impacts in Vietnam may thus plausibly represent an upper bound on bombing impacts more generally.

This study employs an unusual United States military district-level dataset on bombs, missiles, rockets and other ordnance dropped in Vietnam. 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 584 districts in the sample. Figure 1 shows the geographic location of the 10% most heavily attacked districts (in terms of total U.S. bombs, missiles and rockets per km^2).

The heaviest bombing took place in Quang Tri province in the central region of the country near the 17th 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 of its capital and infrastructure destroyed: only 11 of 3,500 Quang Tri villages were left unbombed by 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 Quang Tri itself. Coastal regions of North Vietnam and some districts of Hanoi were heavily bombed, as was the so-called "Iron Triangle", the region adjacent to Cambodia near Saigon in the South. This region was the site of frequent incursions by North Vietnamese troops and Vietcong/NLF guerrillas into South Vietnam through the so-called Ho Chi Minh Trail that ran from North Vietnam through Laos and Cambodia.

There are many reasons to think U.S. bombing could have long-run impacts on Vietnamese economic development. We focus on three factors in particular in the empirical analysis, all linked to neoclassical growth theory. First, the destruction of local infrastructure may have inhibited commerce and possibly changed later investment patterns, pushing some 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).[1] Second, U.S. bombing displaced population, and this could potentially have disrupt local economic activity if many individuals never returned home. Third, population displacement and the destruction of physical infrastructure – including classrooms – disrupted schooling for millions of Vietnamese. In terms of other possible factors, we do not have complete information on unexploded ordnance (UXO), landmines or U.S. Agent Orange use, and unfortunately cannot focus on these in the main empirical analysis (however, there is obviously a strong correlation between bombing and later UXO density).[2]

[1] See Tilford (1991: 155) for further details on the extent of U.S. bombing damage.
[2] 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 declined rapidly relative to the immediate postwar

In this paper, we use the extensive variation in U.S. bombing intensity across 584 Vietnamese districts to estimate long-run impacts of the war. In our main finding, we find no robust negative long term impacts of U.S. bombing on poverty rates, consumption levels, electricity infrastructure, literacy, or population density through 2002. If anything, the more heavily bombed districts have slightly less poverty than other districts. These results are consistent across a variety of specifications and samples. There is suggestive evidence of a moderate negative effect of U.S. bombing on consumption levels in 1992/1993, but also evidence for a positive effect on consumption growth between 1992/1993 and 2002, suggesting that there were negative short-run war impacts on average local living standards but that these dissipated over time as a result of rapid catch-up growth. To be absolutely clear, the human welfare costs of the war in Vietnam – which led to the deaths of millions of civilians by all accounts – were massive even if there are no detectable long-run economic growth impacts.

The key econometric identification issue is the non-random nature of U.S. bombing patterns. If regions with unobservably better economic growth prospects were more (or less) likely to be heavily bombed, this could lead to biased estimates of bombing impacts. Understanding the sources of variation in U.S. bombing is thus critical. In this regard, the identification strategy benefits from at least two factors. First, the most heavily bombed areas were those located near the 17th parallel north latitude, the border between North and South Vietnam during the war. This arbitrarily drawn border, set by the 1954 Geneva Accords that ended the French colonial era in Indochina, became a locus for heavy fighting during the war, and its placement at 17 degrees, rather than 16 or 18 degrees, can be viewed as a natural experiment. The border was not drawn by Vietnamese, but was instead the result of the Geneva negotiations among the major world powers, including the United States and Soviet Union, in the context of the Cold War. We use the north-south distance from a district to the 17th parallel as an instrumental

years (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 best known, 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). Deforestation itself could also negatively affect the environment and agriculture by increasing soil instability and affecting wildlife.

variable for U.S. bombing intensity in our preferred empirical specification, exploiting this source of variation.

The second main concentration of heavy U.S. bombing lies in areas where the Ho Chi Minh Trail entered South Vietnam. While not as clearly exogenous as the North Vietnam-South Vietnam border, the outlets of the Ho Chi Minh Trail into South Vietnam reflected, to a large extent, geographical conditions along the South Vietnam-Cambodia border rather than local socioeconomic conditions within Vietnam. At its main southern outlet, there was less mountainous terrain than is the case farther north along the border, and troop movements were thus easier into the flatlands of the Mekong Delta.

To further address omitted variable bias concerns in the analysis, we perform regressions focusing only on Vietnam's central and southern regions, in areas that 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, as well as province fixed effects in some specifications, to further address omitted variable bias concerns. Finally, we argue below that any remaining bias due to the non-random placement of U.S. bombs is likely to lead to a spurious *negative* correlation between bombing intensity and later income, probably strengthening our main findings.

It is important to note an important limitation up front. While this econometric strategy provides estimates of differences across districts, the approach is unable to capture any aggregate nation-wide effects of the war on subsequent Vietnamese development. The counterfactual – Vietnamese economic performance outcomes in the absence of "the American War" – cannot be observed or estimated. This is a potentially important issue to the extent that the war led to major national institutional and social changes, or if the cross-region spillovers of the war within Vietnam were large. Still the rapid rate of economic growth in 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 rates were not strongly negative.

In 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) 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 these earlier studies. We are able to measure the long run impact of bombing on a far larger set of outcomes than other studies, which either only focus on population effects or on aggregate macroeconomic effects. Indeed, we look at the effect of bombing on (i) variables that are central to understanding economic performance – physical capital, human capital and population – and on (ii) variables that relate directly to human welfare, including poverty rates and consumption. We are thus able to paint a more complete picture of the long run impacts of war.

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

The rest of the paper is organized as follows. Section 2 employs the neoclassical growth model to analyze the long run effect of war on economic performance. Section 3 presents the data. Section 4 discusses determinants of U.S. bombing, the main empirical analysis is presented in section 5, Section 6 elaborates on the mechanisms underlying the results, and the final section discusses broader lessons.

2. War in the Neoclassical Economic Growth Model

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

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

$$\text{s.t. } dK(t)/dt = AF(K(t), L(t), H(t)) - C(t) \qquad (1)$$

where *u(.)* is a concave utility function, *C(t)* is the consumption path in the economy, and ρ is the intertemporal discount rate. The capital stock *K(t)* accumulates with savings *Y(t)–C(t)*, where $Y(t) = AF(K(t), L(t), H(t))$ and *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 exogenous rate *n*, and that the stock of human capital is exogenously given and stationary (although a modification is discussed below). Assuming constant returns to scale, we can rewrite the optimization problem on a per capita basis (lowercase terms denote per capita values):

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

$$\text{s.t. } dk(t)/dt = Af(k(t), h(t)) - c(t) - nk(t) \qquad (2)$$

The Euler equation is:

$$(d\lambda/dt)/\lambda = \rho + n - Af'(k(t)) \qquad (3)$$

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:

$$(dc(t)/dt)/c = \sigma[Af'(k(t)) - \rho - n] \qquad (4)$$

where σ is the intertemporal elasticity of substitution for consumption. The steady state in this economy (k^*, c^*) will be characterized by $dk(t)/dt=0$ and $dc(t)/dt=0$ following from equations (2) and (4). Figure 2 depicts the steady state and phase diagram in *(k, c)* space.

Assume now that war leads to the partial destruction of the physical capital stock in region *i*, such that postwar capital there is $\tilde{k}_i < k^*$, shocking the economy away from the steady state but leaving all model 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 ($\widetilde{k}_i < k^*$) and region *j* where there is no war damage ($\widetilde{k}_j = k^*$). The long-run capital stock and consumption levels are identical in the two regions since none of the model parameters have changed. However, the region that suffered war damage has lower consumption in the short-run and experiences more rapid postwar consumption growth than the untouched region along the transition path back to the steady state, again following from equations (2) and (4).

Although we isolate the consumption effect from a loss of physical capital above for algebraic simplicity, postwar recovery patterns are qualitatively similar 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 result in more rapid postwar accumulation of human capital there, though again there will be no change in steady state outcomes provided that other model parameters are unchanged. We abstract away from issues of local population growth here, in part because the benchmark assumption of free labor mobility largely did not apply in communist postwar Vietnam.

Beyond the loss of physical and human capital, 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^* declines in this case. In particular, the locus $dc(t)/dt=0$ will move to the left (as depicted by the dotted vertical line in Figure 2), and by similar reasoning, from (2) the $dk(t)/dt=0$ 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 postwar.

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 economic performance could diverge across regions that experienced different war impacts. In practice, to the extent that both k_i and A_i are affected by war, it may be difficult empirically to disentangle their separate effects on growth rates in the immediate postwar period (and this is compounded in practice by the difficulties inherent in measuring local institutional quality).

3. The Data

We use a database assembled by the Defense Security Cooperation Agency (DSCA) housed at the United States 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 Vietnam Ministry of Defense Technology Center for Bomb and Mine Disposal.

The database contains information on all ordnance dropped from U.S. and allied airplanes and helicopters in Vietnam between 1965 and 1975, as well as artillery fired from naval ships and sea mines dropped.[3] To our knowledge, these files embody the most complete, comprehensive and reliable summary available of U.S. and allied air and sea ordnance expended during the Vietnam War. Some of the original tape archives were reportedly damaged so up to several months of data may be missing, but unfortunately we are unable to determine the precise extent of any missing data. 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 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, cluster bombs, chemicals, incendiary, rockets, missiles, projectiles, ammunition, mines and flares. Ordnance are measured in 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 the landmine data are thus much less reliable than the other data. The raw data were then geo-coded by VVAF using Vietnam district boundaries

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[3] In particular, data come from the 1965-70 Combat Activities-Air (CACTA), the 1970-1975 South East Asia (SEADAB), and Combat Naval Gunfire (CONGA) databases.

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). The Mark 82 and Mark 36 Destructor general purpose bombs typically weighed between 500 to 750 pounds. Average bombing intensity is high, with an average of 32.3 bombs, missiles, and rockets per km^2 nationwide through the war, 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 many as 561 bombs per km^2.[4] 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 in the analysis on what we call the "Central Region" of the country, which as we define it includes 22 provinces and 229 districts straddling the 17th parallel, 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.[5] Bombing intensity in the Central Region is nearly double that for the nation as a whole and there is also considerably more variation in bombing there. It was overwhelmingly rural at baseline since cities are excluded, making it a particularly useful region to focus on in the analysis since there is far less baseline socioeconomic variation there than in the country as a whole. Comparing the heavily bombed areas only to other nearby districts also located within the Central Region sample can be viewed as a form of matching estimation.

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).

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[4] 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, while still using data from the rest of Quang Tri province.

[5] The provinces in the Central Region are (current names): 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.

While bombing intensity was highest near the 17^{th} 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, as discussed above.

There is a positive and statistically significant correlation across all ordnance categories dropped in a district (Table 1). In the regression analysis below, we mostly employ total intensity of bombs, missiles, and rockets per km^2, but given the substantial correlation with other ordnance categories (e.g. ammunition), this is also 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/NLF. Although we do not have disaggregated data on Agent Orange exposure, the broad regional patterns of Agent Orange exposure correspond rather closely with bombing intensity, as can be seen by comparing the Agent Orange patterns in Stellman et al (2003) with Figure 3 here.

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 2). Note the sharp increase in population density from 1960-61 to the 1999 Vietnam Population and Housing Census. A variety of local geographic and climatic characteristics – including proportion of land at high altitude, average district temperature and precipitation, location in former South Vietnam, and the proportion of land in 18 different soil type categories – are also included as district explanatory variables in most specifications in order to control, at least in part, for agricultural productivity and factors affecting military operations (e.g., altitude). The soil type controls are excluded from the province level analysis due to limited degrees of freedom, as there are only 55 provinces in the final sample.

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 the 17 household characteristics found in both the census and VLSS are then carried out, and the regression results used to compute predicted household consumption (details of the procedure are in the Data Appendix). The poverty rate is defined as the proportion of district population estimated to be living on less than 1,789,871 Vietnamese Dong per year, the official national poverty line, and approximately 41% of the national population meets this criterion (Table 3). The 1999 census also provides detailed information on household access to electricity (71% of households nationwide have electricity) and literacy (88% of respondents), our proxies for past physical and human capital investments, respectively.

We obtained per capita consumption expenditure data from both the 1992/3 and 2002 VLSS waves for a sample of households in a subset of 166 districts, reducing the sample. We focus on province level averages when using the VLSS, since the data was designed to be representative at this level. This data allows us to assess consumption levels and growth during the rapid economic expansion of the 1990s. The VLSS also contains useful retrospective information on migration patterns.

Finally, Vietnamese Statistical Yearbooks provide a consistent series on province population for 1985 to 2000, and some information on total school enrollment and central government investment flows from 1976-1985, data that we utilize in the analysis below.

4. Determinants of U.S. Bombing Intensity

Before presenting the econometric analysis, we discuss the existing literature on U.S. bombing strategy during the Vietnam War. A distinction is often made between the nature of bombing in North Vietnam and South Vietnam. U.S. bombing in North Vietnam was largely considered *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 categorically ruled out. A far broader set of targets in North Vietnam was approved under the

Nixon administration's "Linebacker" campaign, however, including targets in the North's main population centers during the so-called "Christmas Bombing" of 1972.

Bombing in South Vietnam, and in parts of North Vietnam near the border, in contrast, was typically *interdiction bombing* or tactical air support, which aimed to disrupt enemy troop movements and support U.S. ground troop operations, rather than explicitly destroy infrastructure (Littauer et al 1972: 55; Schlight 1988: 292). Below we present empirical results broken down by the former North and South Vietnam, in addition to the full sample estimates, to investigate whether these different bombing strategies led to different long-run economic impacts.

Some of the existing historical research is consistent with the absence of a robust correlation between initial population density and bombing intensity (Nalty 2000: 83), but some other authors suggest that poorer areas were 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).

Turning to the statistical analysis, the north-south distance from the 17th parallel is a strong predictor of bombing intensity and is statistically significant in the province level analysis (Table 3, regression 1), district level analysis (regression 2), and a specification that excludes Quang Tri province, the most heavily bombed province (regression 3), and is large and negative but only marginally significant when we restrict attention to the Central Region (regression 4). The main district level specification in regression 2 serves as the first stage regression for the subsequent IV-2SLS analysis, and note that the instrument is highly statistically significant with a t-statistic near three in that case. In all these specifications and those below, disturbance terms are allowed to be correlated ("clustered") across districts within the same province, in case there are geographic, socioeconomic or political factors correlated among neighboring districts.

None of the other explanatory variables is significantly related to U.S. bombing intensity in a consistent way across the four specifications in Table 3, including the indicator for South Vietnam, altitude measures, climatic conditions and latitude. The one partial exception is the prewar 1960-61 province population density measure, which is negative and statistically significant across all three district level specifications, suggesting that more rural areas were somewhat more likely to be bombed, echoing some of the existing historical literature. However, note that this result does not hold in the province level analysis in regression 1.

Figure 4 graphically presents the relationship between baseline 1960-1 population density and U.S. bombing intensity. Note the very heavy bombing intensity in Quang Tri province. The main empirical results are similar throughout if we consider only the intensity of general purpose bombs, the major ordnance category, or if we consider a log transformation of bombing intensity (results not shown).

5. The Long-run Impact of Bombing Vietnam

5.1 Impacts on Poverty and Consumption Expenditures

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 negative externalities for other nearby districts. Provincial level regressions are one way to partially capture these externalities (although this specification still misses any broader cross-province externalities). Second, the main baseline 1960-61 population density control is at the province level, and thus when population density is the dependent variable at least (in Section 5.3 below), 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 is negatively and marginally statistically significantly related to the 1999 poverty rate at both the province level (Table 4, regression 1, coefficient estimate -0.00087, standard error 0.00048, significant at 90% confidence) and the district level (regression 2, -0.00040, standard error 0.00022). This relationship between bombing intensity and poverty at the district level is presented graphically in Figure 5. In terms of other factors, areas that had higher population density in 1960-61 have significantly less poverty in 1999, as does South Vietnam as a whole on average, while higher altitude areas have considerably higher poverty rates (regressions 1 and 2). Climatic factors and latitude, in contrast, are not robustly associated with poverty rates, although high precipitation districts have significantly higher poverty in some specifications.

The main district level result remains negative and is even more statistically significant in specifications that include province fixed effects (Table 4, regression 3) and exclude Quang Tri (regression 4), but is not statistically significant if attention is restricted to the Central Region sample (regression 5, estimate -0.00017, standard error 0.00019). Overall, the OLS specifications provide suggestive evidence for a moderate negative effect of bombing on later poverty, but estimates are only marginally significant and not particularly robust.

One concern is that this negative relationship 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 correlation. More generally, some other unobserved source of socioeconomic variation could be driving both the observed bombing patterns and later poverty rates. We thus next turn to estimates that rely on the placement of the North Vietnam-South Vietnam border at the 17^{th} parallel as exogenous variation in bombing intensity. In the reduced form specification (Table 4, regression 6), the north-south distance from the 17^{th} parallel is negative but not statistically significantly related to 1999 poverty, conditional on all other province and district geographic factors (coefficient estimate -0.0044, standard error 0.0069). Using this distance as an instrumental variable for U.S. bombing intensity in a district, we find that the relationship between bombing intensity is positive but not statistically significant (estimate 0.00026, standard error 0.00042).

In our preferred IV-2SLS specification (Table 4, regression 7), the coefficient estimate on total U.S. bombing intensity is 0.00026. To get an idea of the magnitude of this bombing impact on later poverty, first consider the effect of a change from zero bombing up to the average bombing intensity of 32.3 bombs, missiles, and rockets per km^2. The average effect in this sense is (32.3)*(0.00026) = 0.008. This is a very small average effect, an increase in the poverty rate by less than one percentage point and it is not statistically significant. In terms of how precise the estimate is, the 95% confidence band ranges from 0.00026 – 2*0.00042 = -0.00058, up to 0.00026 + 2*0.00042 = 0.0011. Thus again considering the effect of going from zero bombing up to the average intensity of 32.3, the 95% confidence band of estimates is (32.3)*(-0.00058) = -0.019 to (32.3)*(0.0011) = 0.035. In other words, plausible average effects range from a 1.9 percentage point reduction in poverty up to a 3.5 percentage point increase in poverty on a base poverty rate of 41%. This is a reasonably tight range of estimates. Carrying out a similar exercise using the preferred OLS estimate (from Table 4, regression 2) yields a point estimate of (32.2)*(-0.00040) = -0.013, a 1.3 percentage point reduction in poverty (going from zero bombing up to average bombing intensity), and a 95% confidence interval from -2.7 percentage point decrease in poverty up to +0.1 percentage point increase, again quite a precise range of estimates near zero.

We next present alternative specifications. The effect of bombing on poverty is negative and statistically significant in former North Vietnam (Table 5, regression 1, coefficient estimate -0.00051, standard error 0.00020) but not in former South Vietnam (regression 2, coefficient estimate -0.00009, standard error 0.00025). The explanation for this North-South difference remains elusive, although the different nature of bombing across the two regions may be part of the story. Bombing effects are not statistically significant in initially rural areas (districts with baseline 1960-1 population density less than 200 per km^2, regression 3) but are statistically significant and negative in urban areas (regression 4). There is some evidence for a nonlinear effect of bombing intensity on later poverty rates: the linear bombing term remains negative and statistically significant while the squared term is positive and significant (regression 5). This pattern may in part reflect the particularly high rates of poverty in Quang Tri province, the most heavily bombed province in the country (as suggested graphically in Figure 5). Point estimates are not statistically significant when an alternative nonlinear measure of high bombing intensity is used (regression 6).

We next explore related relationships using the more detailed VLSS household consumption expenditure data. Average consumption per capita in 2002 is not robustly associated with bombing intensity across the full sample (Table 6, Panel A, regression 1), or in a specification that excludes Quang Tri province (regression 2), restricting attention to the Central Region (regression 3), or in a specification that includes the north-south distance to the 17th parallel as the main explanatory variable (regression 4).

In contrast, all four of these specifications indicate that more heavily bombed provinces were somewhat poorer in 1992/93 (Table 6, Panel B), although none are significant at traditional confidence levels.

Taking the growth rate of per capita consumption expenditures as the dependent variable, we find that provinces that experienced more intense U.S. bombing had significantly faster growth between 1992/93 and 2002 (Table 6, Panel C), and in three of the four specifications this effect is statistically significant at over 95% confidence. The coefficient estimate from the full sample (regression 1) implies that going from zero to average U.S. bombing intensity is associated with (32.3)*(0.0030) or 10 percentage points faster consumption expenditure growth overall during that ten year period, a substantial difference.

These patterns suggest that more heavily bombed areas were somewhat poorer than other areas after the war, but that they later caught up during the Vietnamese economic boom of the 1990s, in line with the neoclassical growth model's prediction of especially rapid consumption growth along the transition path to the steady state. Unfortunately, due to data limitations we cannot trace out consumption growth patterns in the 1970s and 1980s, and so cannot estimate the extent of poverty in heavily bombed areas in the immediate postwar period. Nonetheless, by 2002, nearly thirty years after the U.S. pulled out of Vietnam, the provinces that bore the brunt of the U.S. assault are largely indistinguishable from other areas in terms of average living standards.[6]

5.2 Impacts on Infrastructure and Human Capital

In order to explore the possible sources of differential economic performance across districts, we next examine infrastructure in the 1990s. Infrastructure investment decisions in Vietnam in the 1970s, 1980s

[6] We examined attained adult height as recorded in the VLSS database as a measure of living standards for cohorts born before and during the war, to gauge the extent to which living standards fell in heavily bombed areas. We do find that the average height of the 1961-70 and 1971-80 birth cohorts is significantly lower in more heavily bombed regions. However, it is also somewhat smaller for earlier cohorts born pre-1961 in those areas. The largest coefficient estimate on U.S. bombing intensity (for the 1961-70 cohort) is -0.0165, implying an average reduction of 0.5 cm, when going from zero to average U.S. bombing intensity – not a large effect. The relatively small sample sizes in the VLSS, especially when broken down by year of birth, gender, and province cells, and the possibility that children across a wide range of ages might experience some growth stunting due to the war, do not allow us to draw any strong conclusions from these patterns.

and 1990s likely reflected a combination of central government redistributive goals – perhaps in part to assist areas damaged by the war – as well as potential private returns, especially in the aftermath of economic reforms, and it is difficult to disentangle these motives in the absence of detailed district-level public and private investment data, which we do not have. International donors, non-governmental organizations (NGOs) and even the U.S. government (following the normalization of Vietnam-U.S. relations in 1995) also all played increasingly important roles in funding reconstruction projects during this period, further complicating the picture.

There is a positive relationship between U.S. bombing intensity and 1999 access to electricity across the standard set of province and district specifications (Table 7, panel A), and coefficient estimates are statistically significant at 95% confidence in six of seven specifications. The relationship is weaker when province fixed effects are included as controls (regression 3), but the point estimate on U.S. bombing remains positive and marginally statistically significant even in that case. Note the negative and significant coefficient estimate on north-south distance to the 17^{th} parallel, suggesting particularly intensive electricity investments near the former border. Taken together these estimates provide some suggestive evidence in favor of technological "leapfrogging" in the heavily bombed regions, or possibly investments in heavily bombed regions that far exceeded war damage.

Another factor in the neoclassical growth model is human capital. There is no statistically significant negative impact of bombing on either province or district literacy rates in 1999, an important proxy for human capital investments (Table 7, Panel B, regressions 1-7), and similarly weak results hold for a variety of other 1990s human capital measures from the VLSS database, as well as for 1985 school enrollment per capita from the government yearbooks (results not shown).

Thus taking these 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, consistent with the rapid postwar recovery in consumption levels documented above.

5.3 Impacts on Population Density

Total U.S. bombing intensity in a province during 1965-1975 is not significantly related to province population density in 1999 (Table 8, regression 1), with a point estimate of 0.13 (standard error 0.49). 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 0.89, standard error 0.19) as expected, and former South Vietnam has somewhat higher 1999 population density than former North Vietnam overall, although that difference is only marginally statistically significant. In this province level specification, the effect of a change from zero U.S. bombing up to average province level bombing intensity (presented in Table 1, Panel B) is (30.6)*(0.13) = 4.0 additional people per km^2, a miniscule effect with a tight 95% confidence range from -26 to +34 people per km^2, less than 0.1 of a standard deviation in 1999 province population density (Table 2, Panel B).

In a variety of district level OLS specifications, total U.S. bombing intensity is not statistically significantly related to 1999 district population density (Table 8, regression 2-5). Similarly, in neither the reduced form regression of population density on the north-south distance from the 17^{th} parallel (regression 6), nor the IV-2SLS specification (regression 7) is the key explanatory variable statistically significantly related to 1999 district population density. However, one caveat to all of the district level population results are the large standard errors on the key coefficient estimates, which make these estimates far less precise than the poverty results reported above (in Tables 4 and 5). The leading explanation for these large standard errors in the district level regressions is the absence of a prewar *district* level population density control: province population density in 1960-61 is only weakly correlated with 1999 district population density, in sharp contrast to the precisely estimated province level results (for instance, in Table 8, regression 1).

There is also 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 and South Vietnam, in rural areas (districts with baseline 1960-1 population density less than 200 per km^2), and when province fixed effects are included for all Vietnam and using alternative measures of bombing intensity (regressions not shown). Note that for urban areas, the estimated effect of bombing is positive in some specifications but the result is not robust (regressions not shown).

We next trace out effects on population density over time from 1985 to 2000. Using data from Vietnamese Statistical Yearbooks, we find no effect of bombing intensity on population density in 1985 (Table 9, Panel A). We also find no effects on province population density growth rates from 1985 to 2000 (Panel B). So unlike for consumption (Table 6), there is no evidence of population "catch-up" growth. Moreover, as was the case for 1999 population, there is no statistically significant effect of U.S. bombing on province population density in any year from 1985 to 2000 (results not shown). When we compare the evolution of population density across 1985, 1990, 1992, 1994, 1996, 1998, and 2000 for the more heavily bombed regions (above median bombing) relative to the less heavily bombed (below the median), the slope is essentially zero (Figure 6). This suggests that if there were any population movements into the more heavily bombed regions after the war, they must have occurred prior to 1985.

Unfortunately, disaggregated population figures, as well as other official demographic and economic measures, are often incomplete for the postwar 1970s and early 1980s, preventing us from extending this analysis back to the immediate postwar period. Thus it remains possible that there were in fact short run war effects on population that had dissipated by the mid 1980s.

It remains theoretically possible that this lack of postwar population density effects is due to large postwar inflows of migrants into the heavily bombed districts, but while we cannot rule this out, nor do we find any compelling evidence that this is in fact the case. Using the 1997/8 VLSS data, U.S. bombing intensity does not have a robust statistically significant effect on the proportion of individuals not born in their current village of residence (Table 9, Panel C), although the point estimate is positive and marginally statistically significant in one specification (excluding Quang Tri province, regression 2). Note that one limitation of this analysis is the inability to capture flows of people who left Vietnam altogether.

6. Why No Long-run Impact?

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, based on our empirical analysis as well as our reading of the existing historical literature. First, much U.S. bombing targeted South Vietnam with the purpose of impeding the progress of enemy troops (both North Vietnamese Army and Vietcong/NLF guerrillas), 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 physical infrastructure that did exist. First of all, some industrial operations were dispersed across multiple sites (Kamps 2001: 70). Second, 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). Although we lack district-level investment data for the postwar period, Vietnamese government yearbooks contain information on total state investment by province during the period 1976-1985. For 1985 alone we are able to construct per capita state investment figures (complete province population data is only available to us for 1985), and find that provinces that were more heavily bombed during the war did in fact receive greater postwar state investments (in millions of 1985 Dong per capita): in a specification analogous to Table 6, column 1, the point estimate on total U.S. bombing intensity is 0.0113 (standard error 0.0071, regression not shown), and this effect is nearly statistically significant at 90% confidence. Over the entire period 1976-1985, the ratio of state investment flows for provinces above the median in terms of U.S. bombing relative to provinces below median bombing is 2.0; in other words, the more heavily bombed provinces received twice as much state investment as other provinces on average. Figure 7 presents the time path of the ratio of state investment in the more heavily (above median bombing) relative to less heavily (below the median) bombed provinces from 1976 to 1985, and shows that the ratio is always larger than one, and increases strongly during the 1980s up to a maximum ratio of 2.6 in 1985. These patterns provide strong evidence that the Vietnamese government made efforts to allocate additional resources to the more heavily bombed regions. They may explain some leapfrogging in infrastructure investment, and may have also laid the foundation for the rapid catch-up growth in consumption discussed above.

In terms of population, the displacement caused by bombing 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).

Finally, despite the war, large-scale school expansion and literacy campaigns were carried out during the 1960s and 1970s, especially in North Vietnam, where promoting literacy was a central social goal of the regime (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 often had foxholes and helmets for students' protection during U.S. attacks (Duiker 1995, Nguyen Khac Vien 1981).

7. Conclusion

We found no robust long run impacts of U.S. bombing on local poverty rates, consumption levels, or population density in Vietnam over 25 years after the end of "the American War". If anything, the bulk of the empirical results point to moderate reductions in long-run poverty and somewhat better electricity access in the areas hit by more U.S. bombing, as well as faster consumption growth during the 1990s. Given that the bombing of Vietnam was the most intense episode of bombing in world history, this is perhaps a surprising result. There is evidence of substantial reallocation of Vietnamese government resources towards the regions that were more heavily bombed, and this can plausibly explain at least part of the absence of long run impacts.

As discussed above, our econometric approach compares more heavily bombed areas to others and thus cannot estimate any nation-wide effects of the war on Vietnamese economic development. The counterfactual – Vietnamese economic performance in the absence of the war – is impossible to reconstruct. If the regions not greatly affected by the war assisted the more heavily bombed regions through postwar resource transfers, as our state investment data suggest, then differences between the more and less heavily bombed areas would be dampened but overall Vietnamese living standards could still have fallen. In that case, the actual aggregate effects of U.S. bombing on long run Vietnamese economic performance would be more negative than our estimates imply.

On the other hand, the war undoubtedly fostered a strong sense of Vietnamese 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 the war has clearly not prevented Vietnam from achieving rapid economic growth: Vietnamese economic growth in terms of GDP per capita has recently been among the fastest in the world, at 6% per year between 1993 and 2003 (World Bank 2004), following the reforms of the 1980s and 1990s.

Caution is called for, however, in drawing broader lessons regarding war's impacts on economic growth in general. Unlike many other poor countries, postwar Vietnam benefited from strong, centralized political institutions able to mobilize human and material resources in the reconstruction effort. Vietnam also emerged successfully from war out of a long struggle for national liberation[7] against a series of foreign occupiers (first the French, then the Japanese briefly, and finally the United States), an experience that provided its postwar leaders considerable nationalist political legitimacy.

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[7] The conflict in Vietnam was 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.

In contrast, the bulk of wars in the world today are internal civil conflicts, which may exacerbate political and social divisions and weaken national institutions rather than strengthen them. The world's most conflict prone region is Sub-Saharan Africa, where state institutions are notoriously weak (Herbst 2000). In such a setting, postwar reconstruction may drag on far longer than in Vietnam (or in Japan, where postwar political institutions were also strong) leading to more persistent adverse legacies of war. Civil conflicts may be inherently more damaging for local institutions and social cohesion than external wars, since the civil war's winners and losers continue to interact in politics and in everyday life. Due to the uniqueness of each society's institutions, politics, and history, in our view further empirical evidence accumulated across a variety of cases is needed before making general claims about the effects of war on long run economic performance.

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

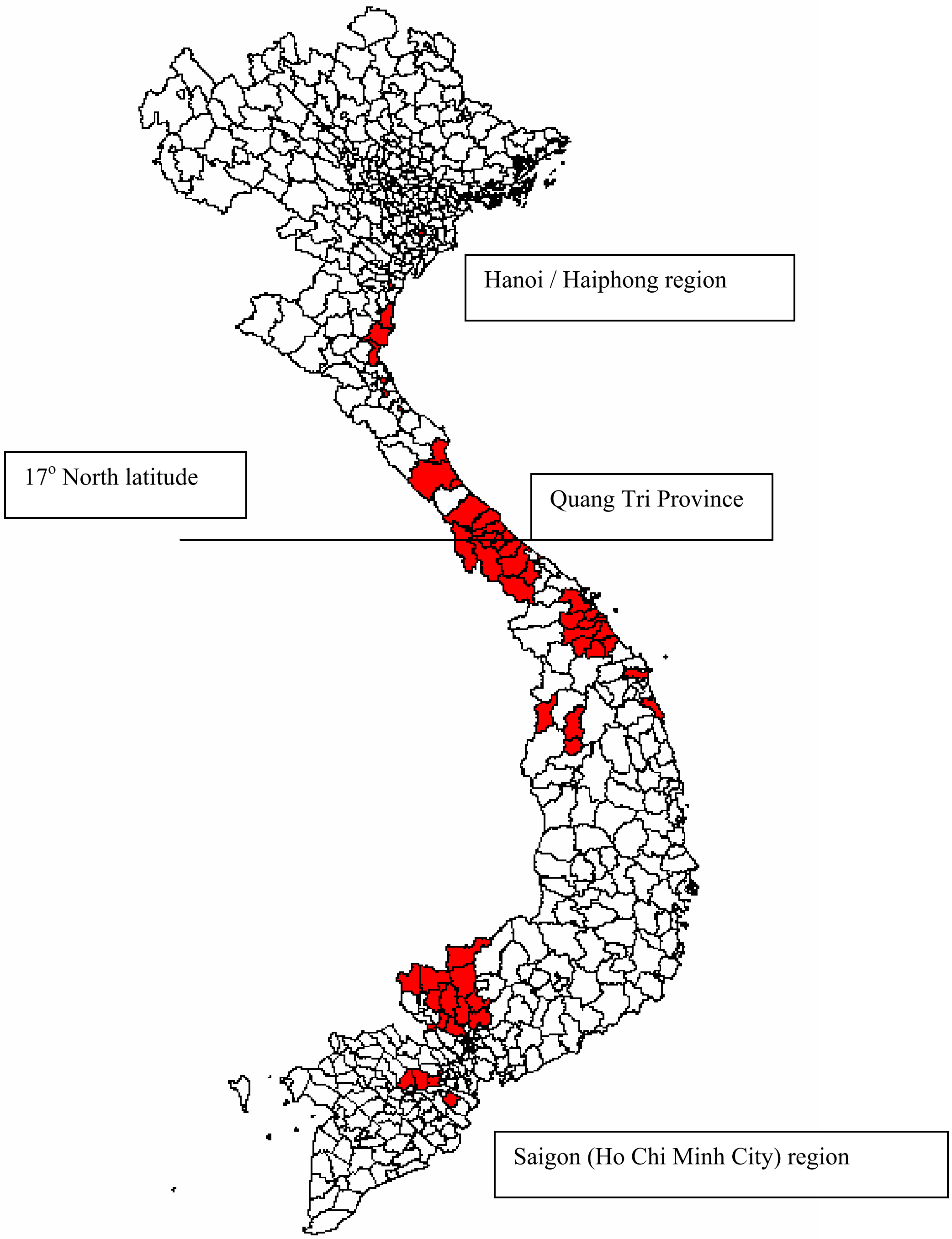


Figure 2: Phase diagram for the Ramsey model,
in per capita consumption (c) versus per capita physical capital (k) space

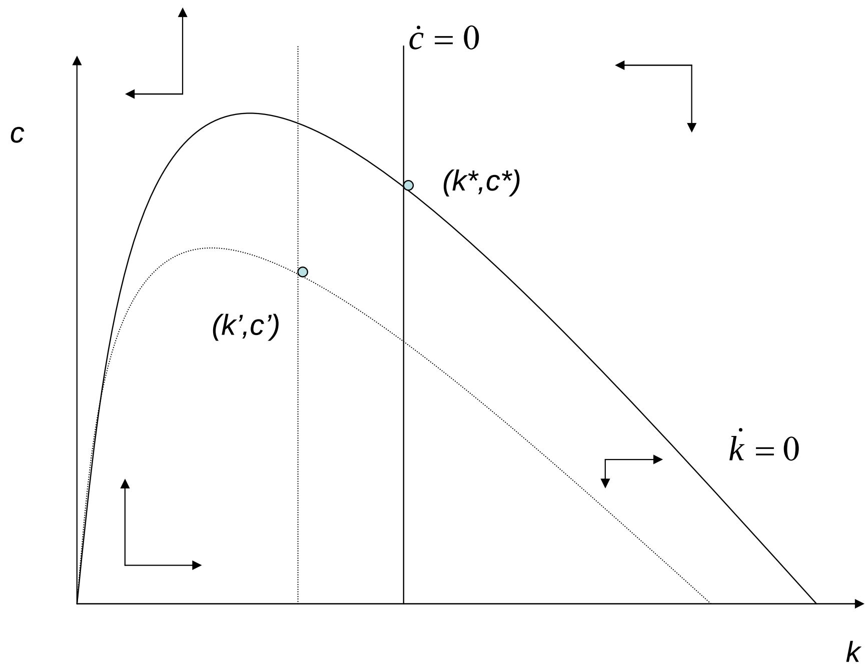


Figure 3: Map of Vietnam – Total U.S. bombs, missiles, and rockets per km^2
(20 quantiles, darker colors denote higher intensity districts)

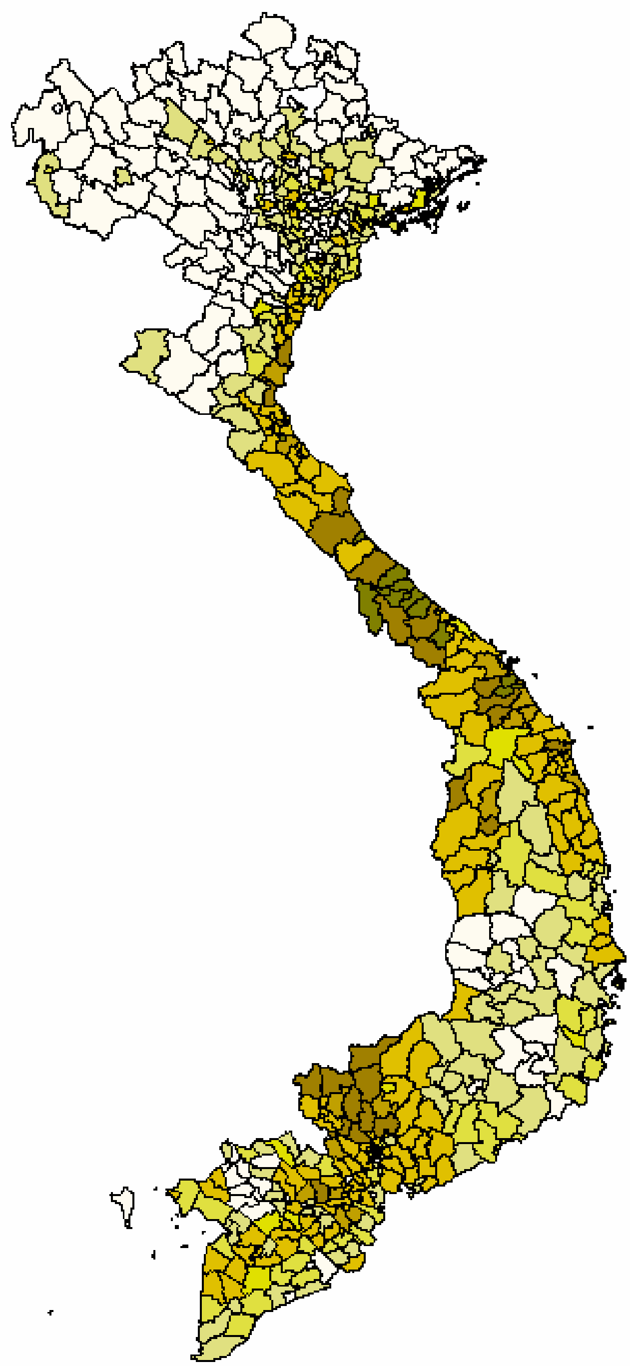


Figure 4: 1960-61 province population density vs.
Total U.S. bombs, missiles, and rockets per km^2 in the province

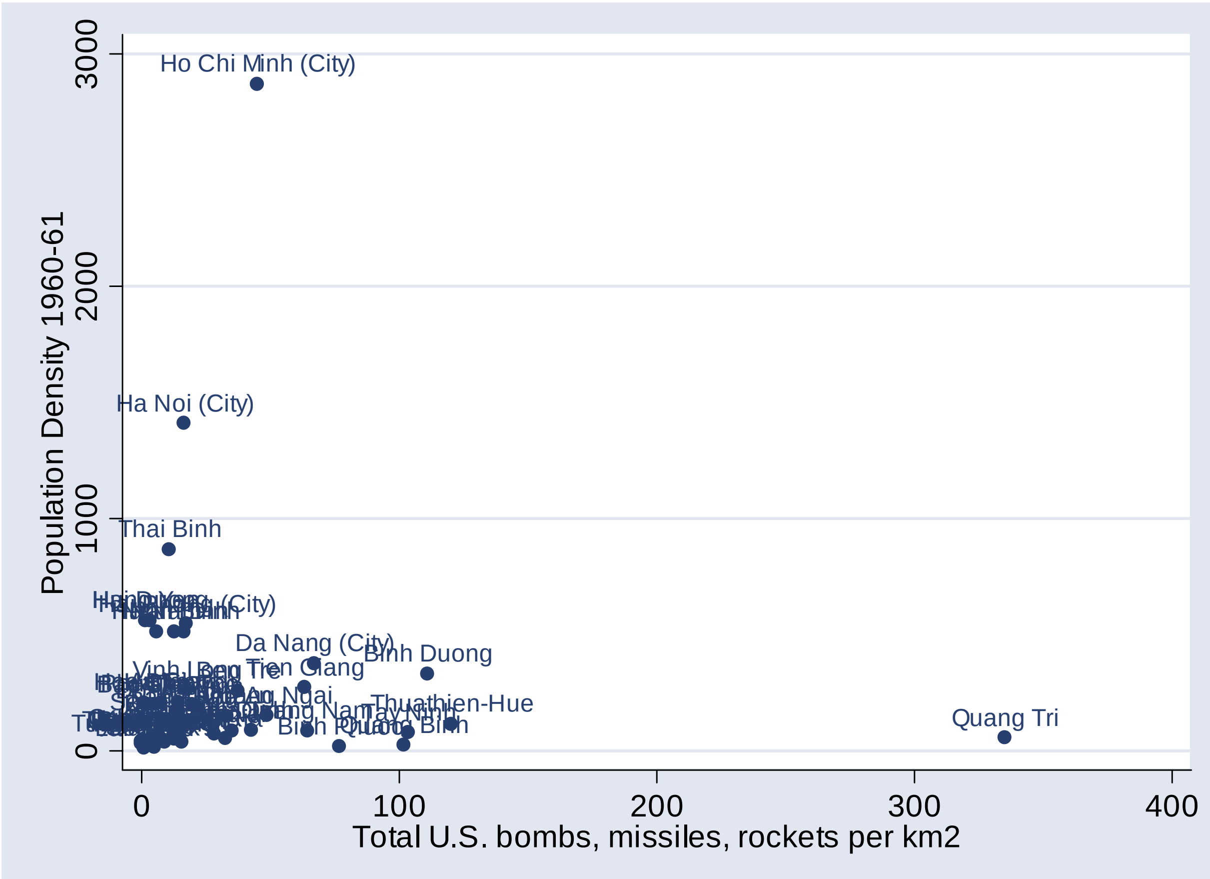


Figure 5: 1999 estimated district poverty rate vs.
Total U.S. bombs, missiles, and rockets per km^2 in the district
(conditional on 1960-61 province population density, South Vietnam indicator, district average temperature, average precipitation, elevation, soil controls, and latitude)

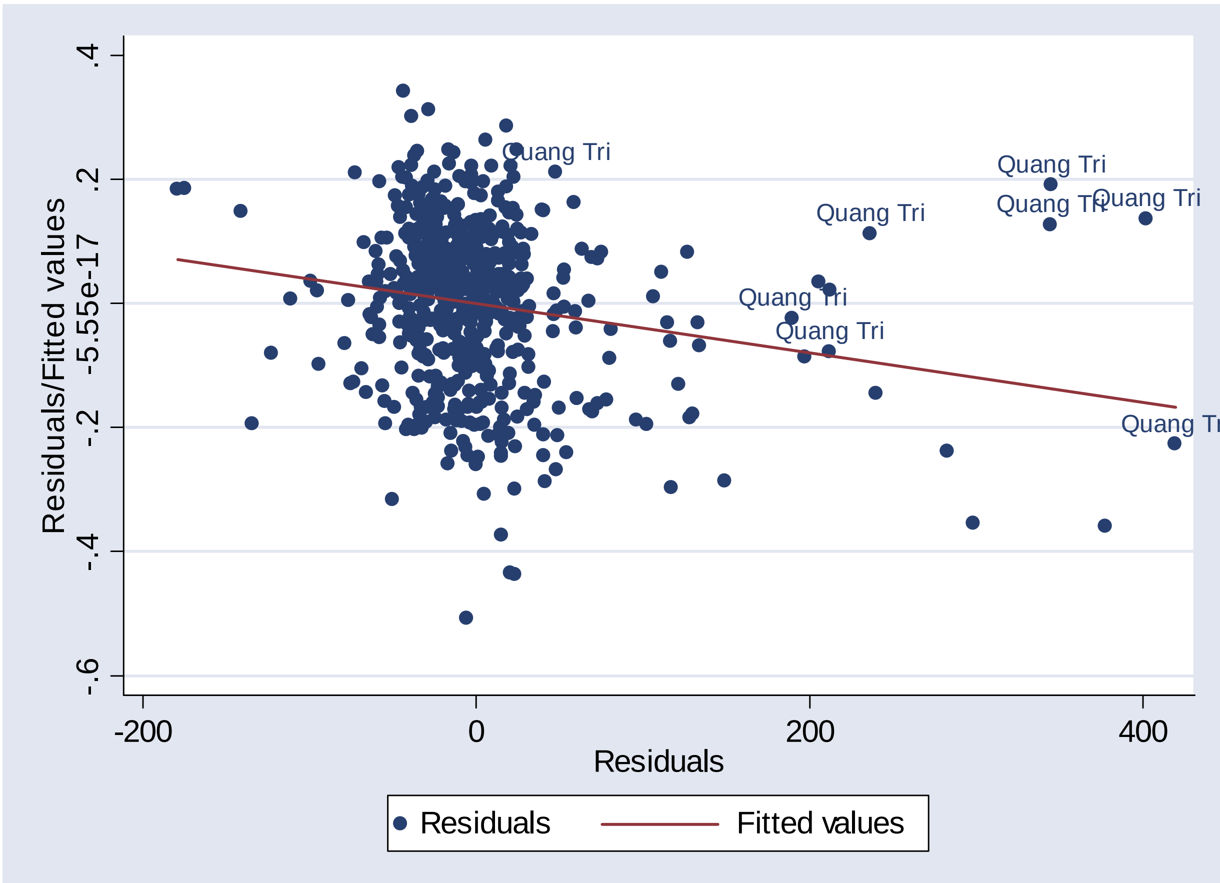


Figure 6: Population Density in 1985-2000,
ratio of more heavily bombed (above median) to less heavily bombed (below median) provinces

Figure 7: State investment 1976-1985,
ratio of more heavily bombed (above median) to less heavily bombed (below median) provinces

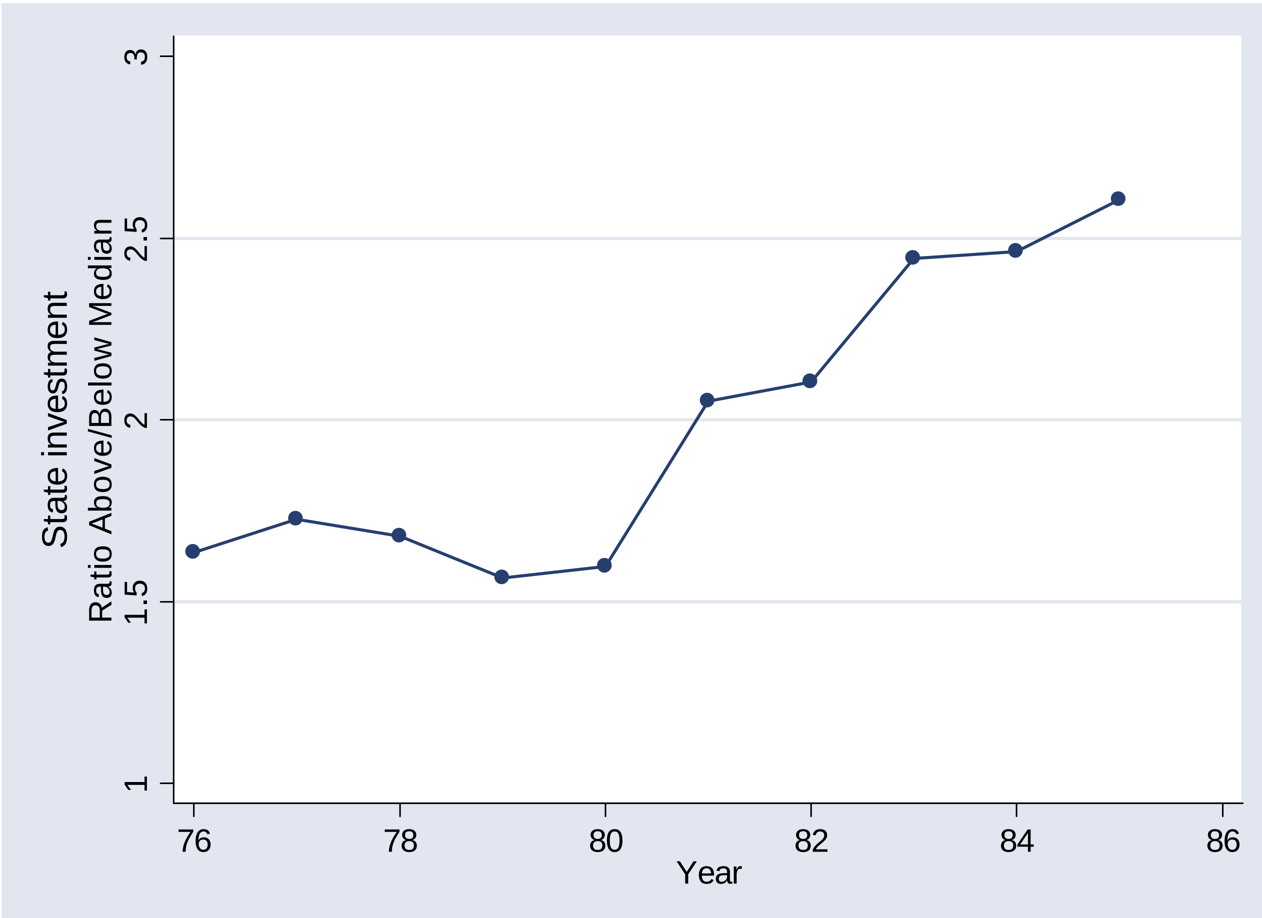


Table 1: Summary statistics – U.S. ordnance data

	Mean	S.D.	Max.	Obs.	Correlation with general purpose bombs
Panel A: District level data					
Total U.S. bombs, missiles, and rockets per km^2	32.3	68.5	561.5	584	
Total U.S. bombs, missiles, and rockets	14692	37349	365449	584	
General purpose bombs	11124	30779	322111	584	1
Cluster bombs	706	2268	32403	584	0.59***
Missiles	24.7	121.7	1600	584	0.27***
Rockets	2828	7208	106445	584	0.64***
Cannon artillery	8.6	51.9	772	584	0.37***
Incendiaries	795	16431	11667	584	0.65***
White phosphorus	70.7	306.6	3580	584	0.27***
Ammunition (000's of rounds)	5677	11061	136416	584	0.54***
Panel B: Province level data					
Total U.S. bombs, missiles, and rockets per km^2	30.6	51.7	335.5	55	

Notes: The summary statistics are not weighted by population. The minimum value is zero for all variables at the district level, and thus we do not present this in the table. The sample throughout excludes Quang Tri district (one 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 throughout. Significant at 90 (*), 95 (**), 99 (***) percent confidence.

Table 2: Summary statistics – economic, demographic, climatic, and geographic data

	Mean	S.D.	Min.	Max.	Obs.
Panel A: District level data					
Estimated district poverty rate, 1999	0.41	0.20	0.03	0.94	584
Population density, 1999	1659	5846	10	2332	584
Proportion of households with access to electricity, 1999	0.71	0.27	0.08	1	584
Literacy rate, 1999	0.88	0.11	0.24	0.99	584
Proportion of land area 250-500m	0.11	0.19	0	1	584
Proportion of land area 500-1000m	0.11	0.21	0	1	584
Proportion of land area over 1000m	0.03	0.11	0	1	584
Total district land area (km^2)	529	513	4	3230	584
Average precipitation (cm)	154.6	30.1	84.2	282.0	584
Average temperature (celsius)	24.3	1.9	19.4	27.3	584
Former South Vietnam	0.49	0.50	0	1	584
Latitude (^oN)	18.0	5.2	9.7	25.4	584
| Latitude – 17^oN |	4.9	2.0	0.0	8.4	584
Panel B: Province level data					
Population density (province), 1960-61	244	437	12	2868	55
Population density, 1985	401	533	34	3196	53
Population density, 1999	465	540	62	2908	55
Change in population density, 1985-2000	77.7	154.5	-439.4	745.1	53
Proportion not born in current village, 1997/98	0.26	0.23	0	1	55
Per capita consumption expenditures, 1992/93 (in 1998 Dong)	1831	591	997	3546	55
Per capita consumption expenditures, 2002 (in 1998 Dong)	3084	1007	2040	7505	55
Growth in per capita consumption expenditures 1992/93-2002	0.74	0.38	-0.08	1.67	55
Latitude (^oN)	17.6	5.4	10.0	25.2	55
| Latitude – 17^oN |	5.0	2.0	0.3	8.1	55

Notes: The summary statistics are not weighted by population. District latitude is assessed at the district centroid, and province latitude is the average of the district latitudes, weighted by district land area.

Table 3: Predicting bombing intensity

	Dependent variable: Total U.S. bombs, missiles, and rockets per km^2			
	(1)	(2)	(3)	(4)
| Latitude – 17^{o}N |	-14.8***	-17.0***	-10.2***	-27.8
	(5.3)	(6.0)	(2.2)	(16.2)
Population density (province), 1960-61	0.0050	-0.0035**	-0.0034**	-.163*
	(0.0043)	(0.0016)	(0.0014)	(0.083)
Former South Vietnam	-138.5*	-134.5	-37.1	-171.3
	(74.9)	(87.2)	(27.7)	(118.8)
Proportion of land area 250-500m	89.5*	-27.6	-26.6*	-104.5*
	(47.1)	(20.5)	(14.2)	(54.9)
Proportion of land area 500-1000m	-49.6	-17.7	-10.5	-52.2
	(65.3)	(18.9)	(16.8)	(31.8)
Proportion of land area over 1000m	156.3*	-6.0	-19.8	-50.6
	(81.4)	(30.4)	(19.1)	(31.2)
Average precipitation (cm)	0.26	0.22	0.16*	0.09
	(0.17)	(0.18)	(0.08)	(0.31)
Average temperature (celsius)	15.2	-0.2	-0.6	7.6
	(0.8)	(4.4)	(3.6)	(5.6)
Latitude (^{o}N)	-8.7	-10.0	-2.3	-15.5
	(6.3)	(7.1)	(2.6)	(12.9)
District soil controls	No	Yes	Yes	Yes
Exclude Quang Tri province	No	No	Yes	No
Central Region sample	No	No	No	Yes
Observations	55	584	576	229
R^2	0.54	0.33	0.25	0.43
Mean (s.d.) dependent variable	30.6 (51.7)	32.3 (68.5)	27.1 (50.6)	56.7 (91.0)

Notes: Ordinary least squares (OLS) regressions. Robust Huber-White standard errors in parentheses. Significant at 90(*), 95(**), 99(***) percent confidence. Disturbance terms are clustered at the province level in regressions 2-4. The district soil type controls include the proportion of district land in 18 different soil categories. The omitted altitude category is 0-250m.

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).

Table 4: Local bombing impacts on estimated 1999 poverty rate

	Dependent variable: Estimated poverty rate, 1999						
	OLS	OLS	OLS	OLS	OLS	OLS	IV-2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Total U.S. bombs, missiles, and rockets per km^2	-0.00087*	-0.00040*	-0.00065***	-0.00079***	-0.00017		0.00026
	(0.00048)	(0.00022)	(0.00012)	(0.00016)	(0.00019)		(0.00042)
Population density (province), 1960-61 (÷100)	-0.0089***	-0.0021**		-0.0023**	-0.013	-0.0021**	-0.0020*
	(0.0016)	(0.0009)		(0.0010)	(0.010)	(0.0010)	(0.0010)
Former South Vietnam	-0.317***	-0.174**		-0.122*	-0.005	-0.139**	-0.104
	(0.087)	(0.071)		(0.071)	(0.047)	(0.058)	(0.082)
Proportion of land area 250-500m	0.341***	0.339***	0.182***	0.325***	0.285***	0.342***	0.349***
	(0.096)	(0.070)	(0.067)	(0.069)	(0.111)	(0.070)	(0.073)
Proportion of land area 500-1000m	0.386**	0.261***	0.157**	0.261***	0.161**	0.253***	0.257***
	(0.172)	(0.052)	(0.062)	(0.053)	(0.064)	(0.054)	(0.055)
Proportion of land area over 1000m	0.571**	-0.048	-0.001	-0.066	-0.187**	-0.044	-0.043
	(0.231)	(0.113)	(0.159)	(0.111)	(0.086)	(0.120)	(0.116)
Average precipitation (cm)	-0.00027	0.00111***	0.00060	0.00110***	0.00070*	0.00068*	0.00063
	(0.00044)	(0.00035)	(0.00046)	(0.00033)	(0.00036)	(0.00038)	(0.00044)
Average temperature (celsius)	0.033	-0.012	-0.034	-0.013	-0.0373	-0.0143	-0.0143
	(0.029)	(0.019)	(0.022)	(0.020)	(0.0219)	(0.0196)	(0.0199)
Latitude (^{o}N)	-0.0127	-0.0088	0.038	-0.0044	0.0211**	-0.0051	-0.0025
	(0.0108)	(0.0088)	(0.026)	(0.0088)	(0.0092)	(0.0081)	(0.0100)
| Latitude – 17^{o}N |						-0.0044	
						(0.0069)	
District soil controls	No	Yes	Yes	Yes	Yes	Yes	Yes
Province fixed effects	No	No	Yes	No	No	No	No
Exclude Quang Tri province	No	No	No	Yes	No	No	No
Central Region sample	No	No	No	No	Yes	No	No
Observations	55	584	584	576	229	584	584
R^2	0.75	0.61	0.79	0.63	0.72	0.60	-
Mean (s.d.) dependent variable	0.39 (0.16)	0.41 (0.20)	0.41 (0.20)	0.41 (0.20)	0.43 (0.20)	0.41 (0.20)	0.41 (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 2-8. The district soil type controls include the proportion of district land in 18 different soil categories. The omitted altitude category is 0-250m. The instrumental variable in regression 7 is | Latitude – 17^{o}N |.

Table 5: Local bombing 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	All Vietnam
	(1)	(2)	(3)	(4)	(5)	(6)
Total U.S. bombs, missiles, and rockets per km^2	-0.00051**	-0.00009	-0.00021	-0.00088**	-0.00114***	
	(0.00020)	(0.00025)	(0.00021)	(0.00017)	(0.00033)	
(Total U.S. bombs, missiles, and rockets per km^2)^2 (÷100)					0.00019***	
					(0.00006)	
Top 10% districts, total U.S. bombs, missiles, and rockets per km^2						-0.030
						(0.026)
District demographic, geographic, soil controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	300	284	409	175	584	584
R^2	0.70	0.66	0.60	0.65	0.62	0.60
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)	0.41 (0.20)

Notes: Ordinary least squares (OLS) regressions. Robust Huber-White standard errors in parentheses. Significant at 90(*), 95(**), 99(***) percent confidence. Disturbance terms are clustered at the province level. District demographic and geographic controls include Population density (province) 1960-61, Former South Vietnam, Proportion of land area 250-500m, Proportion of land area 500-1000m, Proportion of land area over 1000m, Average precipitation (cm), Average temperature (celsius), and Latitude (^{o}N). The district soil type controls include the proportion of district land in 18 different soil categories. The omitted altitude category is 0-250m.

Table 6: Local war impacts on consumption expenditures and growth (VLSS data)

	OLS (1)	OLS (2)	OLS (3)	OLS (4)
Panel A: Dependent variable: 2002 per capita consumption expenditures				
Total U.S. bombs, missiles, and rockets per km^2	2.4	5.3	-1.4	
	(1.7)	(3.4)	(1.6)	
| Latitude – 17°N |				3.3
				(54.5)
Exclude Quang Tri province	No	Yes	No	No
Central Region sample	No	No	Yes	No
Observations	55	54	20	55
R^2	0.61	0.62	0.69	0.60
Mean (s.d.) dependent variable	3084 (1007)	3092 (1014)	2898 (689)	3084 (1007)
Panel B: Dependent variable: 1992/93 per capita consumption expenditures				
Total U.S. bombs, missiles, and rockets per km^2	-1.5	-2.0	-1.1	
	(1.0)	(2.2)	(0.7)	
| Latitude – 17°N |				53.9
				(48.1)
Exclude Quang Tri province	No	Yes	No	No
Central Region sample	No	No	Yes	No
Observations	55	54	20	55
R^2	0.46	0.44	0.59	0.47
Mean (s.d.) dependent variable	1831 (591)	1847 (585)	1773 (583)	1831 (591)
Panel C: Dependent variable: Growth in consumption, 1992/93-2002				
Total U.S. bombs, missiles, and rockets per km^2	0.0030***	0.0036**	0.0015	
	(0.0007)	(0.0017)	(0.0010)	
| Latitude – 17°N |				-0.057**
				(0.028)
Exclude Quang Tri province	No	Yes	No	No
Central Region sample	No	No	Yes	No
Observations	55	54	20	55
R^2	0.47	0.41	0.56	0.41
Mean (s.d.) dependent variable	0.74 (0.38)	0.72 (0.37)	0.73 (0.46)	0.74 (0.38)

Notes: Robust Huber-White standard errors in parentheses. Significant at 90(*), 95(**), 99(***) percent confidence. All regressions contain controls for Population density (province) 1960-61, Former South Vietnam, Proportion of land area 250-500m, Proportion of land area 500-1000m, Proportion of land area over 1000m, Average precipitation (cm), Average temperature (celsius), and Latitude (°N). The omitted altitude category is 0-250m.

Table 7: Local war impacts on infrastructure and human capital

	OLS (1)	OLS (2)	OLS (3)	OLS (4)	OLS (5)	OLS (6)	IV-2SLS (7)
Panel A: Dependent variable: Proportion of households with access to electricity, 1999							
Total U.S. bombs, missiles, and rockets per km^2	0.00168***	0.00036***	0.00025	0.00043**	0.00025*		0.0019**
	(0.00055)	(0.00012)	(0.00016)	(0.00017)	(0.00013)		(0.0009)
| Latitude – 17^{o}N |						-0.033***	
						(0.009)	
District soil controls	No	Yes	Yes	Yes	Yes	Yes	Yes
Province fixed effects	No	No	Yes	No	No	No	No
Exclude Quang Tri province	No	No	No	Yes	No	No	No
Central Region sample	No	No	No	No	Yes	No	No
Observations	55	584	584	576	229	584	584
R^2	0.59	0.57	0.75	0.57	0.62	0.58	-
Mean (s.d.) dependent variable	0.72 (0.21)	0.71 (0.27)	0.71 (0.27)	0.71 (0.27)	0.67 (0.26)	0.71 (0.27)	0.71 (0.27)
Panel B: Dependent variable: Proportion of literate respondents, 1999							
Total U.S. bombs, missiles, and rockets per km^2	0.00005	0.00003	0.00009	0.00012**	-0.00003		0.00041
	(0.00012)	(0.00006)	(0.00006)	(0.00006)	(0.00006)		(0.00037)
| Latitude – 17^{o}N |						-0.0070	
						(0.0052)	
District soil controls	No	Yes	Yes	Yes	Yes	Yes	Yes
Province fixed effects	No	No	Yes	No	No	No	No
Exclude Quang Tri province	No	No	No	Yes	No	No	No
Central Region sample	No	No	No	No	Yes	No	No
Observations	55	584	584	576	229	584	584
R^2	0.65	0.59	0.75	0.59	0.55	0.59	-
Mean (s.d.) dependent variable	0.89 (0.07)	0.88 (0.11)	0.88 (0.11)	0.88 (0.11)	0.86 (0.11)	0.88 (0.11)	0.88 (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 2-8. All regressions include Population density (province) 1960-61, Former South Vietnam, Proportion of land area 250-500m, Proportion of land area 500-1000m, Proportion of land area over 1000m, Average precipitation (cm), Average temperature (celsius), and Latitude (^{o}N). The district soil type controls include the proportion of district land in 18 different soil categories. The omitted altitude category is 0-250m. The instrumental variable in regression 7 is | Latitude – 17^{o}N |.

Table 8: Local bombing impacts on 1999 population density

	Dependent variable: Population density, 1999						
	OLS	OLS	OLS	OLS	OLS	OLS	IV-2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Total U.S. bombs, missiles, and rockets per km^2	0.13	2.0	12.4	6.1	-0.1		-13.9
	(0.49)	(8.9)	(10.9)	(12.5)	(0.6)		(19.7)
Population density (province), 1960-61	0.89***	0.66		0.68	2.21***	0.67*	0.62
	(0.19)	(0.42)		(0.42)	(0.43)	(0.40)	(0.45)
Former South Vietnam	282.7*	857.9		344.4	-81.9	1048.9	-821.7
	(145.2)	(1890.2)		(1735.1)	(180.5)	(862.8)	(2899.1)
Proportion of land area 250-500m	-1332***	-3997	-1416	-3890	-37.4	-3845	-4230
	(426)	(3125)	(1721)	(3133)	(138.5)	(2830)	(3272)
Proportion of land area 500-1000m	13	-2164	-1762	-2181	101.9	-1829	-2075
	(261)	(1661)	(1460)	(1686)	(145.1)	(1370)	(1586)
Proportion of land area over 1000m	-1468***	-1264	-111	-1084	327.9**	-1316	-1399
	(489)	(1983)	(1722)	(2014)	(151.8)	(1745)	(1982)
Average precipitation (cm)	-1.27**	-22.7	-9.9	-22.7	-0.79	-14.1	-11.0
	(0.55)	(15.6)	(9.2)	(15.4)	(1.19)	(11.2)	(10.5)
Average temperature (celsius)	-46.7	767.3	470.0	774.9	77.0	828.0	824.6
	(49.2)	(846.7)	(373.6)	(1849.4)	(59.2)	(887.3)	(882.9)
Latitude (^{o}N)	36.9**	103.2	-1317.1	60.4	-29.0	91.0	-48.1
	(16.5)	(177.5)	(904.5)	(164.4)	(26.3)	(120.2)	(266.0)
| Latitude – 17^{o}N |						237.1	
						(328.6)	
District soil controls	No	Yes	Yes	Yes	Yes	Yes	Yes
Province fixed effects	No	No	Yes	No	No	No	No
Exclude Quang Tri province	No	No	No	Yes	No	No	No
Central Region sample	No	No	No	No	Yes	No	No
Observations	55	584	584	576	229	584	584
R^2	0.86	0.16	0.56	0.15	0.52	0.15	-
Mean (s.d.) dependent variable	465 (540)	1659 (5846)	1659 (5846)	1678 (5884)	406 (605)	1659 (5846)	1659 (5846)

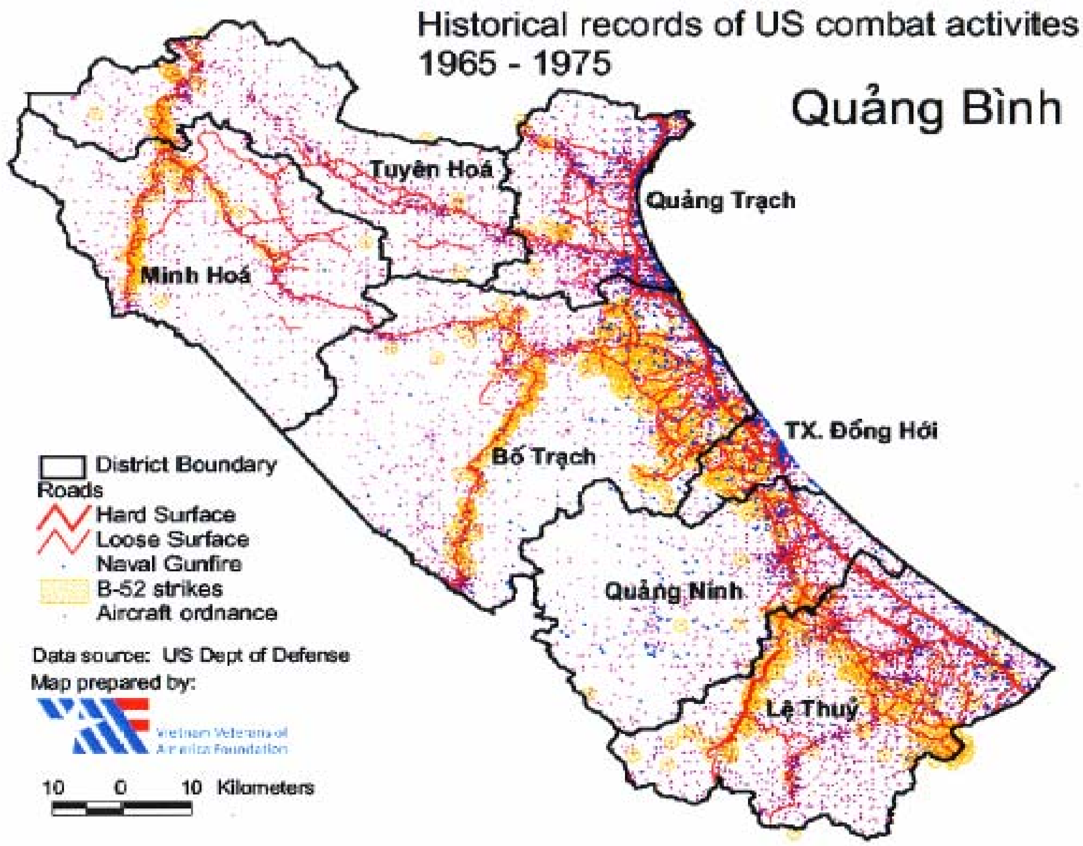
Notes: Robust Huber-White standard errors in parentheses. Significant at 90(*), 95(**), 99(***) percent confidence. Disturbance terms are clustered at the province level in regressions 2-8. The district soil type controls include the proportion of district land in 18 different soil categories. The omitted altitude category is 0-250m. The instrumental variable in regression 7 is | Latitude – 17^{o}N |.

Table 9: Local war impacts on other population characteristics

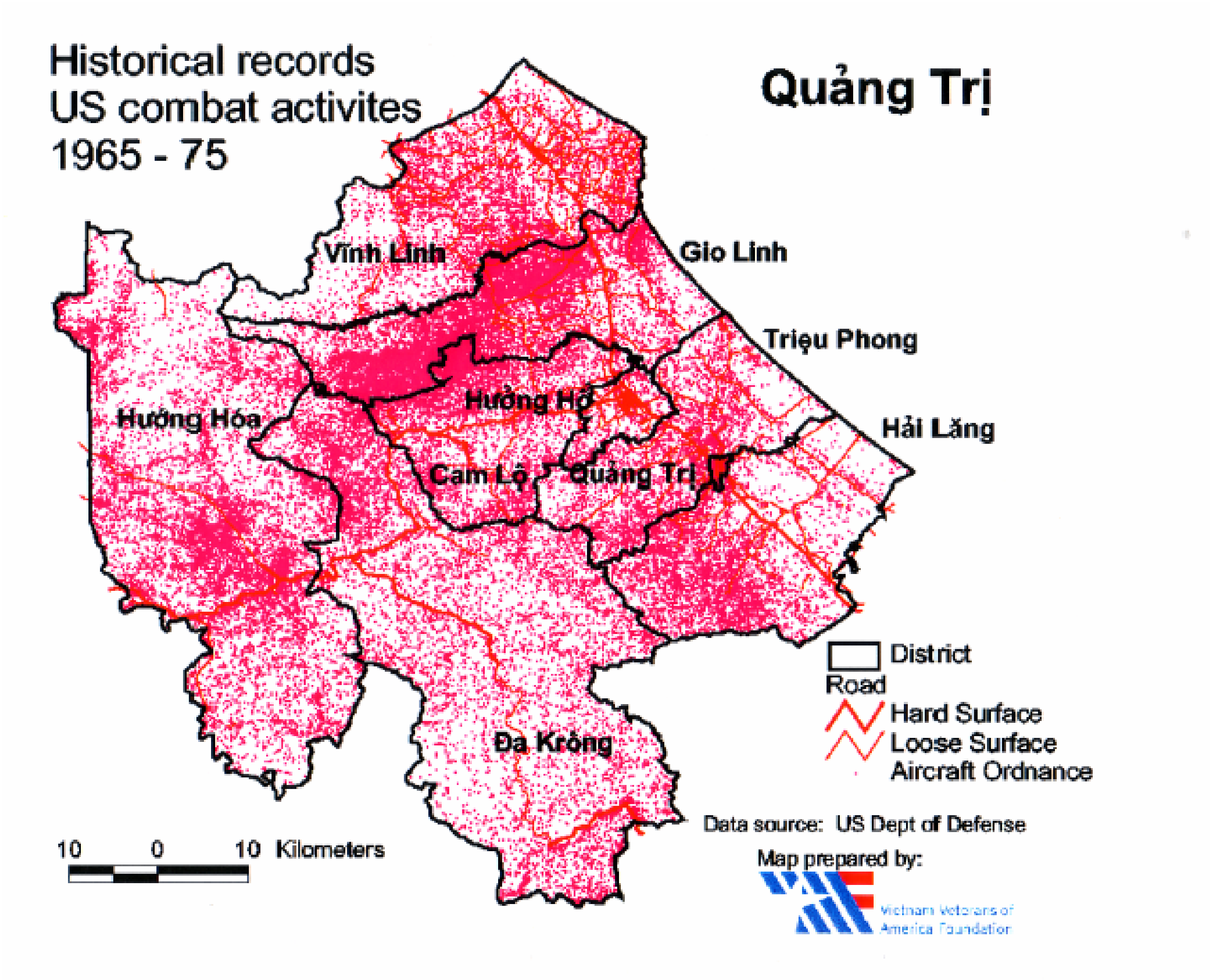
	OLS (1)	OLS (2)	OLS (3)	OLS (4)
Panel A: Dependent variable: Population density, 1985				
Total U.S. bombs, missiles, and rockets per km^2	-0.18	-0.99	-0.10	
	(0.58)	(1.15)	(0.24)	
| Latitude – 17°N |				-2.3
				(10.4)
Exclude Quang Tri province	No	Yes	No	No
Central Region sample	No	No	Yes	No
Observations	53	52	20	53
R^2	0.73	0.73	0.55	0.73
Mean (s.d.) dependent variable	401 (533)	407 (536)	139 (72)	401 (533)
Panel B: Dependent variable: Growth in population density, 1985 to 2000				
Total U.S. bombs, missiles, and rockets per km^2	-0.008	0.090	-0.211	
	(0.164)	(0.362)	(0.274)	
| Latitude – 17°N |				7.5
				(6.5)
Exclude Quang Tri province	No	Yes	No	No
Central Region sample	No	No	Yes	No
Observations	53	52	20	53
R^2	0.24	0.24	0.50	0.24
Mean (s.d.) dependent variable	77.7 (154.5)	78.7 (155.8)	59.5 (84.0)	77.7 (154.5)
Panel C: Dependent variable: 1997/98 proportion not born in current village				
Total U.S. bombs, missiles, and rockets per km^2	0.00037	0.00127*	-0.00091	
	(0.00041)	(0.00069)	(0.00066)	
| Latitude – 17°N |				0.006
				(0.016)
Exclude Quang Tri province	No	Yes	No	No
Central Region sample	No	No	Yes	No
Observations	55	54	21	55
R^2	0.52	0.43	0.70	0.51
Mean (s.d.) dependent variable	0.27 (0.23)	0.27 (0.23)	0.34 (0.30)	0.27 (0.23)

Notes: Robust Huber-White standard errors in parentheses. Significant at 90(*), 95(**), 99(***) percent confidence. All regressions contain controls for Population density (province) 1960-61, Former South Vietnam, Proportion of land area 250-500m, Proportion of land area 500-1000m, Proportion of land area over 1000m, Average precipitation (cm), Average temperature (celsius), and Latitude (°N). The omitted altitude category is 0-250m.

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



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



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 allied 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 thousands 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 the Technology Center for Bomb and Mine Disposal (BOMICO), 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 these are 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 (that 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 shells 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. army troops.
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 = 12.7 mm), 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, an 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 1999 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 and 2002 VLSS survey rounds.

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 characteristics 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, and 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 1999 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 official national 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 1980s and 1990s are from the Vietnam Statistical Yearbooks (Vietnam General Statistical Office). Unfortunately, we have been unable to locate complete and consistently defined province level demographic data from the mid-1970s through the mid 1980s. The Yearbooks also contain information on total state investment flows and total school enrollment by province from 1976-1985, data that is also used in the statistical analysis.

(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 those data in the analysis.

A final data source we considered is the HAMLA/HES database collected by the U.S. government starting in South Vietnam in 1967-68 (described in Kalyvas and Kocher 2003), which collected rough proxies for village socioeconomic conditions. The two main drawbacks of this data is that first, the exact procedure for assigning the local SES measures is not transparent or well-described in existing sources, and second the data was collected several years into the war, and thus may be endogenous to earlier U.S. bombing patterns. For these reasons we do not utilize this data in the empirical analysis.