

A Semi-Parametric Spatial Regression Approach to Post-War Human Security: Cambodia, 2002–2004

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Abstract Human security in post-war societies depends on incentives to forego violence in local interactions. The government of Cambodia monitors domestic violence, land conflicts and serious crime in over 13,000 villages and urban neighbourhoods. We use three annual data collections to estimate the response of these conflicts to the legacy of the war, poverty and resource competition, urbanity as well as governance quality. Bayesian spatial regressions help identify socio-economic thresholds beyond which conflicts expand or contract significantly. We find numerous non-linearities in the propensities for violence. Notably, predicted rates decrease in response to quality of governance only at a high level of service provision, which, realistically, most communities may not soon achieve. This may justify dedicated programmes addressing particular types of conflicts. We propose alternative analytic approaches, including some that would make the problem of endogeneity more tractable once updated poverty estimates become available.

Keywords Human security · Semi-parametric spatial regression · Post-war society · Cambodia

Introduction

Local communities in post-war countries recover unevenly. Do those in more favourable socio-economic conditions offer their residents better security? Do threats to life and the integrity of persons diminish apace with the recovery, or do they linger at elevated levels until growth and development have crossed certain thresholds? Should policy assume that

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economic opportunity and public service provision will take care of the risk of violent conflict, or does it call for direct intervention?

This article takes advantage of a rich database of local conflicts, many of them violent, in Cambodia to shed light on such questions. To do so, we focus on non-linear associations between social and economic conditions and post-war human security at the community level. Although local-level studies of the nexus between socio-economic development and violent conflict are less common than those relying on country-level data, more of them have appeared in recent years and have refined insights, linking them more closely to policy considerations. Deininger's study from Uganda is seminal in this line (Deininger 2003).

Where such studies use statistical models, these tend to be parametric, assuming that the effects on levels of conflict are uniform across observed ranges of the socio-economic covariates. At most, expected non-linear effects are modelled through pre-defined functional forms, chiefly as squared terms.

In contrast, our study employs Bayesian methods to allow full expression of non-linear effects, letting the "data speak for themselves." We choose these methods over other non-parametric models, such as local regression, because they admit spatial dependency in count data models. The results reveal thresholds in the factors that exacerbate or diminish conflict, some of which are dramatic. Non-linear effects are present on the levels of all three types of conflict that are distinguished in the database—domestic violence, land conflicts, and serious crime—and are, for some factors, similar across the three.

For example, in a typical community in the year 2002, we predict that 1 in every 57 households had a domestic violence problem during the year, close to the observed 1:55 rate. At that point, an important governance indicator—the fraction of households with access to safe water—stands at 35%. Other factors remaining constant, improved water provision initially is associated with very little change in domestic violence; the rate edges to 1:58 (at 55% safe water access), then to 1:60 (75%). Then, after another such increment (to 95%), the violence rate drops disproportionately to 1:69.

By "factors", we mean explanatory variables that one may also consider as indicators taken from four potential causal domains—the legacy of the war, poverty and resource competition, urbanity, and the quality of governance. The conflict and indicator data is available for virtually all of the 1,628 local communes in Cambodia; this allows us to control for spatial dependency.

Our analysis strategy remains cross-sectional, despite the fact that the conflict event counts and some of the socio-economic variables were recorded for three consecutive years. This is so primarily because of reliability concerns (addressed below). Consequently, and in the absence of conflict-resistant instruments, we cannot answer questions of endogeneity. Such effects—from conflict and violence to socio-economic development—are plausible, particularly in an aid-dependent country like Cambodia, where the presence and effectiveness of development agencies depend on a minimum of local security. Therefore our findings are limited to associations between development and conflict, without establishing causality. Throughout, the focus remains on non-linear community–contextual risk factors in inter-personal violence.

Earlier, we estimated the effects of those factors using parametric models (Owen and Benini 2005: and subsequent analyses of the entire 2002–2004 data set). Key findings were:

- Better governance dampens violence. Using proxies for the cumulative effects of development agencies, significant effects on all types of violence appear.
- The intensity of the war has a lingering effect on violence; however, with the passage of time, it has become weak compared to the strength of other factors.

- Severe poverty breeds violence. Violence is much more frequent in communities with higher destitution and with keener competition for resources.

This article examines whether those relationships are linear or change disproportionately once communities cross certain socio-economic thresholds. Also, it tests the significance of the relationships more rigorously by controlling for unobserved factors, to the extent that these are spatially correlated.

The article proceeds as follows: after briefly surveying the relevance of high-levels of interpersonal conflict and violence for socio-economic development, we reference select findings from a small number of micro-level studies. Some of these are set in countries still at war (e.g. Uganda, Colombia), yet appear relevant to post-war situations. We then relate to the work of others the four explanatory domains that serve as an ordering device between the socio-economic covariates and the conflict data.

Next we present our data. For space reasons, we have placed all tables, including data sources, descriptive statistics, and associations among covariates, in a Statement on Replication available as supplementary online material at doi:[10.1007/s11417-008-9056-1](https://doi.org/10.1007/s11417-008-9056-1). In the main article we discuss aspects of the reliability of the data and of the validity of their use for our models. Next, we justify the motivation for Bayesian methods. Our models, which use the same set of explanatory variables and contiguity map across conflict types, mix fixed (year effects), linear and semi-parametric specifications. For space reasons again, the stages of estimation and inference as well as the estimates of the fixed and linear effects are presented in the Statement on Replication.

We focus the reader's attention on a matrix graph that arranges the effect curves of the semi-parametrically modelled covariates by conflict type. We point out important differences between Bayesian model results and those from the earlier parametric models (both are reported in detail in the Statement on Replication, together with the thresholds of socio-economic variables for the non-linear effects). We discuss the meaning of those results for development and violence studies and suggest some lines for future work, some of which are inspired by approaches used in other fields, such as disease mapping.

This article cannot address a number of relevant related themes. The human security framework for this Cambodia data was given in our earlier work; Mack (2005: VIII) and Owen (2002) discuss reasons for isolating personal security and treating violence as a dependent variable in models of human security. The decades of violent conflict that decimated Cambodia have been chronicled and analysed in many scholarly works, some of which are classics for the interested reader (Kiernan 1996; Heuveline 1998; Valentino 2004).

Violence and Socio-economic Development

Domestic, political and criminal violence are antithetic to human security. Research linking them to broader development concerns expanded in the 1990s (Heise et al. 1994; Fajnzylber et al. 1999; Ellsberg et al. 2001), in response to types of conflicts surging from the collapse of the Cold War order. Goodhand (2003) reviews the linkages between violent conflict and chronic poverty in both directions, concluding that the causal arrow from violence to poverty is stronger than vice versa.

Violent acts, however, are not evenly distributed within post-war countries. Their variation in space and alongside socio-economic and war-legacy conditions is a much younger field of study. Deininger (2003) spells out motivations for studies disaggregated within affected countries. Cross-country model findings are not sufficiently close to factors

on which policy conclusions may hinge; they are too broad to unravel two-way causation paths between conflict and poverty. Deininger's findings, based on community and household data from Uganda, cut both ways. With conflict on the dependent side, he demonstrates that the factors to which political violence responds are not the same as those operating on crime aimed at individuals (this result is important for studies like ours that estimate effects on different kinds of conflicts and violence). Conversely, economic recovery is inhibited by local civil strife.

We highlight another recent micro-level study, for the size of the database as well as for some methodological concerns that it shares with ours. Barron et al. (2004) exploit data that a government census in Indonesia returned from more than 69,000 villages and neighbourhoods, to find that 7% of those units reported local conflict during the previous year. A quarter of the reported conflicts involved fatalities. These estimates result from key informants; the authors find significant underreporting when comparing those claims with the findings of more in-depth studies of a sample of communities. While definitions of conflict lack precision, quantitative analysis nevertheless establishes that "poverty by itself has very little correlation with conflict. Changes in economic conditions, on the other hand do. [For example,] ... unemployment is universally closely associated with higher conflict rates" (Barron et al. 2004, p 31).

A feature increasingly seen in micro-level studies of violence and poverty is the explicit modelling of spatial dependence. The dependence may be substantive or simply a data problem. Certain types of perpetrators (e.g. robbers) move between communities and districts, constituting a human diffusion process. Neighbouring units may also be correlated on unobserved factors that foster violence. Conversely, measurement error may be larger in certain contiguous areas, such as in crime underreported from sparsely populated rural communes. Studies that grow out of a sample survey tradition (Deininger's (2003) Uganda study in the World Bank's Living Standards Measurement Surveys) or the one from Indonesia with her non-contiguous island areas limit controls to second-level parameters (mostly as fixed effects for a district or region). In an intermediate step to spatial modelling, Demombynes and Ozler (2002), studying crime and inequality in post-apartheid South Africa, invent a makeshift "criminal catchment area" made up of neighbouring police districts. More canonical formulations, using distance or adjacency-based measures, are still rare in the field; Sánchez et al. (2003) analyse the relationship between the armed conflict and the different manifestations of violence and criminal activity in Colombia through a combined time and spatial lag model. Our models, while not dynamic, are spatial.

Explanatory Domains and Indicators

At the basis of our models are four socio-economic domains that we believe have a strong nexus with local conflict and violence. They are, as already mentioned, the legacy of the war, poverty and competition for resources, urbanity and the quality of governance (Fig. 1). In this section, we discuss the theoretical importance of these domains, the indicators for which we have data and their relationship to the concepts, and refer to the descriptive statistics. Definitions and statistics for the three conflict types that respond to them will follow later.

War Legacy

Ember and Ember (1994) argue that war socialises violence, leading to the legitimisation of violent interpersonal conflict resolution. Its mirror-image companion process is the

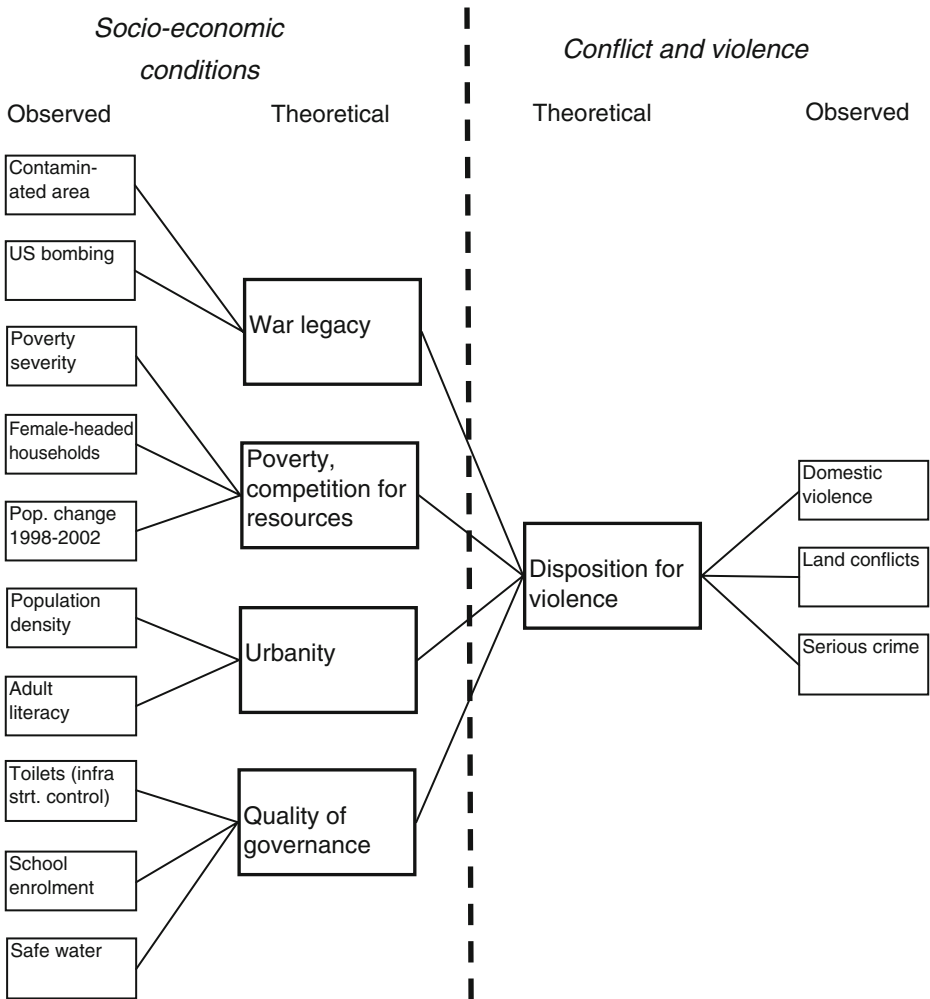


Fig. 1 Conflict model schematic

destruction during war of social capital that leads to heightened risks of violence in post-war society (Colletta and Cullen 2000; Goodhand et al. 2000).

Our study measures the war legacy at the commune level through two variables, the land contaminated with landmines and unexploded ordnance, as well as the intensity of United States bombing. The Cambodia Landmine Impact Survey reported that 6,422 out of 13,863 villages were affected by landmines or unexploded ordnance, that 2.5% of the country’s surface area may be contaminated and that 5.1 million out of the 11.4 million population were at risk (International Campaign to Ban Landmines 2003). In the period 1965 to 1973, the United States Air Force dropped over half a million tons of bombs onto Cambodian territory (this figure goes back to Shawcross 1987). The bombing data is from the United States Government (DSCA 2004) and is described in Miguel and Roland (2005, p 48). For both variables, we use magnitudes rather than ratios to commune area or population; the rationale is given in Owen and Benini (2005, p 16). What is missing for a fuller capture of

the war legacy is data on the demographic footprint of war and genocide; in the extant population census data, it is not possible to separate lingering genocide effects from recent migration effects¹.

Poverty and Resource Competition

No less complex than those of the war legacy, the effects of poverty and resource competition on post-war conflict and violence are difficult to detail. Fajnzylber et al. (1999) investigate linkages to violent crime in a dynamic cross-country framework. They conclude that the income share of the poor does not affect crime rates once income inequality is accounted for. With land conflicts, poverty should be positively associated because marginal farmers will be socially weak and will be tempting targets for violent removal; they may also use violent means to defend their status (Simmons 2004). Finally, poverty is likely to exacerbate intra-household conflict because coping with extraordinary needs such as a health crisis is more difficult; this should manifest itself in more frequent domestic violence (for a review of the linkages between poverty and domestic violence, see Benson et al. 2003; Brush et al. 2003).

We use three measures to capture poverty and resource competition at the commune level: the severity of the poverty, the fraction of households headed by women, and the magnitude of the population change between the years 1998 and 2002. Three poverty measures—head count, poverty gap and poverty severity—were estimated for each commune for the year 1998, using small-area estimation techniques that combine sample survey and population census data. The methodology is described in detail in Fujii (2003). Severity, which emphasises the number of the very poor as the measure of choice, was adopted on account of the stronger relationships that it produced in our parametric models; this is in line with the findings of Fajnzylber et al. (1999). Since 1998, no further countrywide commune-level poverty estimates have been produced (Do 2005).

As an additional poverty measure, and one that is thought to capture levels of absolute destitution (Devereux 2003), we also use the proportion of female-headed households. We use estimates by the same local key informants that supplied the conflict counts. Assuming that rapid population influxes lead to keener resource competition, we use the logarithm of the ratio of the 2002 to 1998 local populations as an indicator of this poverty facet. During this period, relative population growth has been stronger in rural than in urban communities; this indicator therefore is not empirically tied to urbanity.

Urbanity

The use of “urbanity” as a concept with explanatory power for post-war violence may surprise readers. This takes into account the mixing of two processes confounded with community population density that may have opposite effects on violence. In the long-run evolution of the modern nation-state, at least in Europe, violence was a phenomenon found primarily in the poor rural areas at the periphery (Eisner 2001). In this context, cities, with their cultural and institutional resources for conflict management, are thought to exert a civilizing, violence-repressing influence. The counter-argument is more recent and is made more often by observers of rapid urbanisation in poor countries. “When combined with economic stress, state failure and increasing calls for democratization, urbanization may

¹ At the local level—i.e. the overall extent of the genocide is the subject of several country-level studies such as Kiernan (2003), Neupert and Prum (2005), and others based on sample surveys, e.g. de Walque (2005).

increase the tendency to unrest and violence” (Koppell and Sharma 2003, p 67) summarises it as a set of interaction effects.

We measure urbanity as literacy and population density. The literacy definitions were construed on the basis of 1998 census variables (persons with at least 6 years of schooling in given age-gender brackets) rather than using the key informant estimates contemporary with the violence years. We find the latter to be so unrealistically high that we prefer to stay with census-based levels from some years ago. This is a similar drawback to the use of the 1998 poverty estimates. We calculated separate rates for male and female literacy; in our final models, we only use male literacy. The reason is that across a variety of parametric models and influence analyses coefficients on female literacy did not produce any intelligible patterns. Population density data is contemporary, i.e. based on population estimates offered by village and neighbourhood leaders in each of the years for which the violence was monitored.

Quality of Governance

The quality of governance as a key factor in solidifying peace and reconstruction has received growing recognition in post-Cold War years (Chr. Michelsen Institute 2004), leading to a donor boom in funding related initiatives. These extend to the local government level (Woodward 2002), in Cambodia notably through the vast decentralization initiative that, among other things, produced the violence data for this study (Andersen 2004).

Theory-supported variables at the local level are not easy to come by for the measurement of governance quality. Our leading idea is to use service level variables that are shorthand for the penetration of local communities by programs emanating from the international community or from higher levels of government. While we cannot measure the quality of services, it is plausible that levels are highly correlated with larger conditions conducive to non-violent conflict resolution, such as access to law enforcement and the quality of local arbitration.

Given data limitations, two indicators are formed from key informant-supplied data to capture governance quality: the fraction of households with access to safe drinking water, and the proportion of girls aged 6–14 who attend school. Safe water provision is a technology that exceeds the self-help capacity of local communities; as a measure of good governance it has received some validation in recent work on how post-apartheid social policies improved service provision in poor South African communities (Beall et al. 2000; Cavill and Sohail 2003). We use female school enrolment rates because effective governance implies the ability to counteract school dropout, which is higher for girls than for boys (McGrew et al. 2004, p 21). To distinguish governance effects from infrastructure effects, we use the fraction of households with sanitary toilets as a control. This latter technology, while responding to public health campaigns, is more flexible and more easily adopted by individual households; it is also more strongly correlated with population density than the two governance indicators.

Conflict and Violence Rates

The SEILA Monitoring System

The conflict and violence data used in this study has been collected by the monitoring arm of the Government of Cambodia’s large decentralisation programme, known by the Khmer

Sanskrit word for foundation stone, SEILA (Andersen 2004, p 2). The enormous range of this monitoring effort contrasts with a notable lack of public documentation of its methods. While reports on various other substantive areas of the SEILA-run monitoring activities are available at the official Web site (SEILA 2005), our understanding of the conflict and violence data generation process was formed during two visits in its headquarters by one of us (Taylor Owen, in 2003 and 2005). By 2005, SEILA had collected key informant estimates of domestic violence, land conflicts and serious crime in four annual drives for the years 2001 to 2004. We were given to understand that the 2001 data was not good. However, SEILA used it in order to give written feedback to most of the commune authorities, offering some comparisons of conflict figures. While we have not seen any of those reports, SEILA staff were unanimous in stressing that these meetings during 2002 were very motivating for commune authorities, who took their participation in subsequent years much more seriously.

We use the data collected for the years 2002, 2003 and 2004. Estimated counts were elicited from headmen and leaders of over 13,000 villages and urban neighbourhoods. The nature of units counted varied between types of conflict. Authorities estimated for their small local communities in the past calendar year:

- The number of households known to have domestic violence problems
- The number of land conflicts
- The number of serious crimes committed. These included murder, robbery, rape and serious theft.

SEILA managed the data in year and province-wise spreadsheets that identify participating units by name and census ID. We aggregated counts to the commune level because some of the covariate data disaggregates only as far as the communes. Also, communes are geo-referenced with polygon shapes while we do not even have point coordinates on the villages.

Conflict Rates

The implications of the conflict definitions and data sources will be discussed after a brief explanation of the rates. Because domestic violence was counted as affected households, we use households as rate denominator for all three types. The number of households was reported by the same key informants who supplied the conflict counts, in each year.

Table 2 in the Statement on Replication supplies the means, population-weighted means, maximum and coefficients of variation (standard deviation/mean) for commune-level rates, together with the fraction of communes that estimated zero events during the reporting year. At this point, some graphic ratios may help the reader:

During an average 1-year observation period, roughly 1 in every 55 households had domestic violence problems; the ratio of land conflicts to households was close to 1:100; and the corresponding ratio for serious crime to households was close to 1:170. The ranges, however, are considerable; the maximum ratios are 1:4 for domestic violence, 1:2 for land conflicts, and 2:3 for serious crime. The mean rate for all three kinds of conflict declined from 2002 to 2004; for measurement error reasons explained further below, however, we do not attempt dynamic explanations.

Validity and Reliability Concerns

From a human security perspective, the ability of the Cambodian government to extract conflict estimates from thousands of local communities covering virtually the entire nation

attests to a considerable (and, given history, non-trivial) degree of administrative penetration. One may speculate whether the mere implementation of government-supervised collection activity brings local communities a measure of protection from violent conflict. As Soares (2004) has shown for crime reporting, the degree of conflict reporting is itself determined by the institutional development of a country.

Key informant-based systems like SEILA's pose both validity and reliability issues. As Barron et al. (2004) noted for Indonesia, conflict definitions are vague. The relationship between conflicts and violence is largely undefined and, except for domestic violence, it is not known what proportion of conflicts involved violence. There are no additional data on fatalities and injuries. Basic observation units differ; they are: affected households (domestic violence), events (serious crime), and possibly multiple units—disputed plots, concerned parties, new cases (land conflicts). “Serious crime” mixes crimes against persons with some types of property crimes. Since it is well known that violent and property crime rates differ in their social-structural determinants (e.g. Kelly 2000; Andrienko 2002), mixed estimates are likely to compromise explanations of varying crime rates. A more general criticism may be levelled at the typology of conflicts used by SEILA. Ninh and Henke (2005), in a study of commune councils, surveyed the prevalence of 12 different types of local conflict. Twenty-four percent of the polled voters held that youth gangs were affecting their families most, outranking the three types of conflict captured in the SEILA reporting (land conflicts: 18%; domestic conflict: 15%; “other crime”: 7%).

The SEILA categories are, a-priori for our study, the result of the particular cognitive workflows organised under the vast decentralisation endeavour. In the SEILA case, as in other monitoring systems that use key informants, estimates are socially conditioned, and one expects systematic differences from other data collection methods. An example each for the dependent and independent variables must suffice here: SEILA's estimates of families with domestic violence problems in 2002 work out as a 2.0% population-weighted mean; by contrast, Bott et al. (2005) report a 2000 survey that found, in a national sample of 2,403 women aged 15–49, 15% assaulted by a partner in the previous 12 months. The male literacy rate (men aged 15+ with 6+ years of schooling) in 1998, based on the population census, was 34%; the key informant-based estimate for 2002 was 79%. Improvements on this scale are not plausible.

We deal with the validity and reliability threats in the following manner. First, for two important covariates, we opt to use the 1998 census-based measures, rather than the more recent SEILA data. For male literacy, we use the census-derived rates because they appear more reliable. For poverty measures, we use the World Food Program estimates extrapolated from census variables, although economic growth and migration may render them obsolete.

Second, we assume that measurement errors in conflict estimates are correlated in ways that the models can partly control. Since instructions for the key informants were passed down a hierarchy, we assume that errors are correlated within administrative units (analogously to supervisor error in sample surveys; see Bassi and Fabbris 1997, p 733). Moreover, since communities assess the consequences of sharing information with outsiders in the light of previous experience and the way they understand current instructions, errors should also have a year-wise component. This differs from the assumption in Fajnzylber et al. (1999, p 9) that measurement error varies little over time.

In response to these caveats, our models include fixed effects of the observation years (with 2002 as the base) as well as spatially unstructured effects of the districts to absorb part of the measurement error. In addition, we introduce commune-level adjacency-based (i.e. spatially structured) effects. These spatial effects, we believe, more validly reflect

substantive influences because measurement errors across district boundaries should be less strongly correlated. Similarly, Zhu et al. (2006) use an unstructured random term and a spatial dependency term side by side in their hierarchical Bayesian models of violent crime events in United States census tracts.

Bayesian Analysis

Our previous parametric work relied on negative binomial regressions, as frequently used in count variable models, especially to overcome the difficulties arising from unobserved heterogeneity in the data. One of our students, Pedersen Dyreng (2004), used the year 2002 segment of the SEILA data to probe the limitation of the parametric approach. She demonstrated that a number of effects were no longer significant once spatial and random effects were taken into account. She also found a small number of covariates with distinctly non-linear effects.

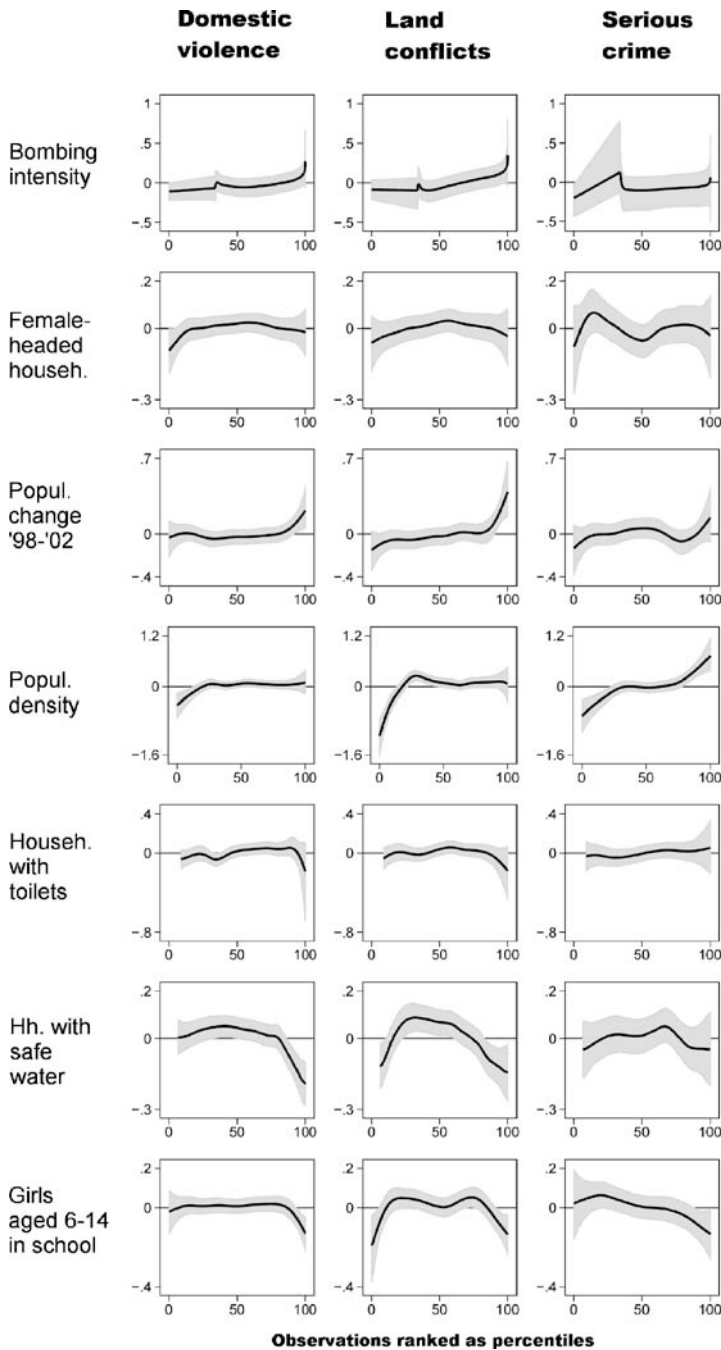
Her results have motivated further Bayesian investigation of our full (2002–2004) data set for the reasons that Fahrmeir and Osuna (2005, p 1) enumerate: Parametric models may suffer from “individual unobserved heterogeneity caused by omitted covariates, temporal or spatial correlation, and possibly nonlinear effects of metrical covariates or time scales”. Moreover, it is usually “very difficult if not impossible to specify nonlinear effects of metrical covariates or of time scales and, in particular, spatial effects a priori through conventional parametric functional forms”.

Semi-parametric Bayesian analysis allows us to mitigate those defects. Its advantages for unravelling causal complexity have been highlighted in political science (Jackman 2000), sociology (Western 2001), criminology (Law and Haining 2004, with special emphasis on spatial effects) and in epidemiology. Bayesian disease mapping (Best et al. 2005) may be the field closest to our research situation, thanks to its methods for concurrent and spatial modelling of several diseases. For background on some of the most prominent modern algorithms through which Bayesian analysis is implemented, we refer again to Jackman (2000, 2004, notably for Markov Chain Monte Carlo simulation) and to Brezger et al. (2005, for spatial effects modelled by Markov random fields or two-dimensional P-splines). The reader interested in the detailed model will find it in the Statement on Replication.

Results

Here we selectively report effects of socio-economic variables as well as of district membership and commune neighbourhood. We proceed by domain in the order of the theoretical exposition. The term “effect” is used abundantly in this paper; in the model context, it strictly means the contribution to the linear predictor of the conflict rates. “Credible interval” is another frequently used term; notwithstanding nuances, it is the Bayesian analogue to confidence interval. We concentrate on the shape and strength of the non-linear effects by comparing graphs with identical y-scales for a given covariate, and x-axes showing all covariates as percentiles. The graphs are arranged in matrix form (Fig. 2), with covariates as rows and types of conflicts as columns. But, we also report effects in the linearly modelled variables where they seem to be of general interest and make frequent comparisons to earlier parametric model results. Complete results are given in the Statement on Replication.

Fig. 2 Matrix graph of semi-parametric effects



Note: Covariates were track-ranked (the lowest value was ranked 1), then transformed to percentiles. As a result of numerous zero values, the lower bound of some ranges (e.g. households with toilets) is at a visible distance above zero. We made an exception for bombing intensity (34 percent of the communes did not suffer air attacks), replacing the lowest percentile with zero so that the credible intervals at that point can be distinguished.

An example will help. The panel in the upper left corner depicts the effect of the United States bombing intensity on domestic violence. This effect is -0.1123 for the 546 communes not subject to air strikes. In other words, at this lower extreme, the model predicts about 11% [$=1-\exp(-0.1123)$] less domestic violence than for the average commune, all other things being equal. This is significant because the credible interval at this point is $[-0.2262; -0.0030]$. At the other extreme, for the five communes on each of which more than one hundred million pounds of bombs were dropped, a mean effect of $+0.2007$ corresponds to roughly a 22% increase. This effect is not statistically significant; because of the small number of observations in this range, the credible intervals contain both positive and negative values.

War Legacy

The Bayesian analysis does confirm the lingering effects of the war legacy that the parametric work revealed. On all three conflict rates, the effect of the linearly modelled landmine and ordnance contaminated area is significantly positive. It is small, however. The rate increase associated with a 1 SD (standard deviation) change of the contaminated area magnitude is between 5 (domestic violence) and 12% (land conflicts).

The effects of the bombing intensity are non-linear. They manifest themselves at or near the extremes of its ranges. In terms of domestic violence and serious crime, communes not bombarded are better off—their predicted rates are 9, and 12% lower, respectively, than those of the rest; this difference is significant. The parametric models had not caught these effects. The effect on land conflicts is significantly positive towards the high extreme; for this group (about 2% of the communes, each the target of over 28 million pounds of bombs) we note an approximate 25% increase in land conflicts. The parametric model too reports such an effect on land conflicts.

Poverty and Resource Competition

In the second of the explanatory domains, poverty and resource competition, the results of the Bayesian and parametric analyses are remarkably different. The Bayesian results are more conservative.

First, poverty severity has a positive effect on all three types of conflict, in both types of models. In the parametric model, the effect is statistically significant for land conflict. In none of the Bayesian models is the coefficient significantly different from zero².

Second, higher proportions of female-headed households, a measure for absolute destitution, are significantly associated with higher violence rates in all three parametric models. The Bayesian analysis produces non-linear effect curves, with effects decreasing towards the high end—perhaps as a result of the scarcity of male perpetrators. These effects, however, are not significant, with a minor exception: Domestic violence is less pronounced in communes that reported a very low proportion (less than 7%) of female-headed households. The predicted rate here is about 12% lower than for the rest of the communes.

The third indicator used for this domain, the magnitude of population change, fully proves its usefulness in the Bayesian context—the non-linear character of the effect is

² The effects on domestic violence and land conflicts just barely miss the significance mark. In the Bayesian estimates of these coefficients, 5.2% are below zero for domestic violence, and 5.8% for land conflicts. The percentage for serious crime is 14.9.

clearly apparent. The parametric models returned significant positive effects on all three types of violence. The Bayesian models, in contrast, show steep take-offs in domestic violence and land conflict rates (and, though not in a statistically credible manner, the crime rate). The rates take off beyond a threshold, near 25% population increase between 1998 and 2002. In these fast-growing commune populations, the effect on domestic violence is a 17% rate increase; for land conflicts, it is 30%.

Urbanity

In the Bayesian models, population density effects are strong, strongly non-linear and, moreover, remarkably different for the three conflicts. The effects climb steadily in the first quartile, from 0.2 to about 70 persons per square kilometre. Thence they flatten out; in fact, in the case of land conflicts, at first slouch back. For serious crime, and only for it, a strong positive effect takes off in the fourth quartile, starting roughly at 300 persons per square kilometre.

Literacy is the other urbanity indicator used here. The final Bayesian models specify the male literacy rate as linear (previous models had failed to show any remarkable non-linear effects). Both the parametric and the Bayesian model coefficients are significantly negative for domestic violence. Under the Bayesian model, an increase from 33.6% male literacy (the 1998 census mean) to 50% would reduce predicted domestic violence by $1/\exp(-0.588 * (0.5 - 0.336)) - 1$, or approximately 10%. Neither approach produces any significant associations between literacy and the other two types of violence.

Quality of Governance

On the two indicators that measure quality of governance—access to safe water and girls' primary education—strong non-linear effects abound. These effects persist when the proportion of households with sanitary latrines is included in the models as a control for infrastructure effects.

The effect curves are all, though to different degrees, shaped as inverted Us. Safe water produces significant positive effects in the middle range and negative effects at one or both extremes, in the domestic violence and the land conflict models, respectively. The shape of the effect on serious crime is similar although the credible interval is nowhere outside zero. The parametric models were able to demonstrate effects of safe water provision in one direction only—and they were not consistent (positive on serious crime, negative on land conflicts and domestic violence).

High female school enrolment is associated with reductions in all types of conflict. Significant effects are evident in the highest decile. This contains the communes that reported enrolment upward from 96%. A dampening of the land conflict rate is at work at the low end as well—significantly so for the 5% communes that reported less than a 50% enrolment. In parametric models, higher female enrolment has a significant negative effect only on serious crime.

Thus, the non-linear effects in the governance domain are numerous. Five out of six effect curves show a pronounced take-off in the higher ranges, and four of those come with credible intervals outside zero. The effect of girls' education on crime grows negative more gradually, without a sharp kink. The predicted reductions in conflicts, moving from the visually inspected "kinks" to the 100-percentile of the governance indicators, are between 16 and 22%. Compared to the effects of population change and population density, these are modest.

Spatial Effects

To repeat, our models take spatial effects into account in two different manners. District-level influences are modelled through a random term, and are interpreted primarily as a part of the measurement error induced by reliance on local key informant estimates. Certainly, there is also a substantive part involved—resulting from the quality of law and order, or the efficacy of land titling. The unobserved aspects vary across the country, but may be relatively uniform within a district. They remain confounded with the measurement error.

At the commune level, we model a structured spatial effect, which we consider genuinely substantive rather than a data issue. Its relative strength can be assessed by comparing the standard deviations of the effects of each of the model terms, as in Table 6 of the Statement on Replication. For example, in the land conflict model, these quantities are 0.65 for the spatial effect, 0.10 for the district effect, 0.11 for the contaminated area, 0.26 for the population density, but only 0.06 for girls' school enrolment.

Across the models, the commune level spatial effects are stronger than any of the other effects. This is a consequence of two factors. First, the effects capture the influence of all unobserved variables to the extent that they are spatially correlated. One would assume that strong spatial correlation is obtained in unobserved war legacy such as the fraction of the local population killed or displaced in the genocide, but also in contemporary conditions such as exposure to natural disasters.

Second, while district membership and commune neighbours were mapped virtually without error, measurement error in the substantive covariates is unknown. Yet, for the same reason (key informant estimates), it may be considerable. If so, the errors attenuate these estimates.

We tested the plausibility of these assumptions by running models identical but for the commune-level spatial term. These model comparisons are detailed in the Statement on Replication. Here we wish to retain that while the commune neighbourhood effects are far stronger than those of any directly measured socio-economic covariates, the significance of including this spatial term is in controlling for unobserved factors. Therefore, those effects of the substantive covariates that are still significant after including the spatial term are more credible.

Discussion

Substantive Aspects of Human Security

Human security in Cambodia, as in other post-war countries, depends on sufficient incentives for peaceful livelihoods to discourage the resumption of violent conflict. That there should be a wealth of significant relationships between socio-economic conditions and conflict rates, therefore, is not surprising.

What is surprising, however, is the relative strength among effects of different factors and the strongly non-linear shape of some of them. Also notable are the location of thresholds below or above which we have noticed steep take-offs, and similarities across conflict types.

Lingering war effects come in two flavours. Those from contamination with explosive remnants of war are linear across its magnitudes and on all conflicts. They are strongest on land conflicts, as one would expect from the land-bound nature of the hazard. By contrast, the effects of the United States bombing seem limited to the extremes of intensity.

Communes that were never bombarded reported lower domestic violence and serious crime whereas land conflicts have responded at the high end. One may speculate that communities with the most severe losses and dislocation find it the hardest to resolve land claims among survivors and returnees.

Although Cambodia as a nation remains deeply marked by the war and genocide experience, the limited effect of the bombing should give pause for thought. It throws up the question (which a cross-sectional study cannot answer) of whether the association between historic war intensity and contemporary conflict is diminishing. In neighbouring Vietnam, Miguel and Roland (2005) found that the United States bombing had no significant impact on local development levels 20 years later. This does not address conflict directly, and the historic distance is longer in Vietnam, but with high levels of internal migration and progress in mine clearance, a diminishing effect seems plausible on conflicts in Cambodia too.

The three indicators in the poverty and resource competition domain are faring unevenly. The Bayesian spatial models make it less certain that the severity of poverty aggravates conflicts; still, its effects on domestic violence and land conflicts are not negligible. A significant non-linear signal travels from the proportion of female-headed households, considered shorthand for absolute destitution, to domestic violence, but not to other conflicts. This plausibly hides reverse causality, with higher domestic violence causing more household break-up. These effects are outdone by those of the local population growth in the 4 years preceding the conflict monitoring period. Population growth was stronger in rural than in urban areas, and thus the conflict-inciting effects of rapid growth reflect competition for resources in rural milieux more than any urbanisation processes.

In the urbanity domain, population density strongly affects the propensity for conflict. The effects take different shapes across conflicts. For example, land conflict rates are much lower in sparsely populated rural communes. The rates hit an upward bump in the second density quartile, only to flatten out as we move to higher ranges, where presumably larger settlements offer more livelihoods that are not land based. Only for serious crime does the curve soar in the high-density range, departing from Broadhurst's observation that homicide rates in the 1990s were lower in urban areas (Broadhurst 2002)³. The effects of literacy are similarly varied; higher male literacy is associated with a reduction only in domestic violence. We may thus conclude that in Cambodia, urbanity, as an institutional complex, is impacting human security in ways that are far from uniform across types of conflict and violence. Intra-rural differences are more important than rural-urban contrasts.

The last of our four socio-economic domains, the quality of governance, is particularly rich in non-linear effects. But this is also the area that calls for the strongest caveats, for two reasons. First, the models do not capture mutual causation between governance and conflict propensity. Second, we assume that the indicators are graded by governance content. The adoption of sanitary latrines is helped by public health campaigns and building ordinances but is essentially left to residential owners. Latrine adoption rates can thus be treated as an infrastructure control. Provision of safe water exceeds the self-help capacity of households and even of most local communities. Girls' primary education ups the ante one more step: it requires not only the organisational continuity of schools but also incentives to retain students. That the effects of safe water and girls' education are stronger than those of toilets speaks for the validity of the governance indicators.

³ We are grateful to a reviewer who pointed out that Broadhurst's observation was only in relation to homicide rates while our definition of serious crimes included also robbery, rape and serious theft. Broadhurst's study showed, among other things, that robbery rates were consistently higher in urban areas.

The provision levels at which conflict-reducing effects take off are relevant in a policy perspective. On domestic violence as well as on land conflict, the impact drops starting from relatively high levels of provision, achieved only in approximately one-fifth of all communes. In addition, land conflicts show an even more dramatic increase at the low end of service provision. This applies also to crime, but faintly so, and even less to domestic violence. One possible interpretation is that, as a village or urban neighbourhood partners with government and non-governmental organisation programmes, its local politics turns more conflictual over bids to control external resources. Conversely, outside agencies may pick up conflict signals and focus projects on communities with more dramatic conflicts in hopes to resolve them or to mitigate causes.

One of the implications seems to be that domestic violence, land conflict and serious crime will not simply go away in the wake of economic growth or greater provision of public goods, but may need to be addressed through specific interventions. This has long been recognised in violence awareness and survivor assistance programs as well as in the massive land titling endeavour across the country.

Methodology

What do we perceive as the most prominent strengths and weaknesses of this study? And how may subsequent work improve on it? First, and most basically, it has been an advantage to obtain data from a monitoring body that covers an entire nation, revisits each collection point over several years, and also provides spatial references at a low aggregation level. Measurements were repeated not only in time, but also in substance when we consider the three kinds of conflicts that SEILA has monitored inter-related facets of human security in Cambodia.

Moreover, the conflict rates are from a full census of local communities, not a sample survey. Covariates too were measured in all 1,628 communes (with the exception of poverty severity, which was estimated from population census and household sample survey data). The uncertainty of the estimates, therefore, is not the result of sample variance, but of measurement error and model mis-specification.

Both are serious. The measurement of conflict, as Barron et al. (2004) pointed out, should use clearer definitions. On the explanatory side, key informant estimates were unreliable (literacy) or absent (poverty) so that we went back to substitutes from the latest population census.

Given the data situation, our analysis remains cross-sectional. This prevents controlling for endogenous effects. Such effects have to be assumed in Cambodia. Notably, areas with high levels of violent crime have deterred the work of development agencies; therefore, governance quality and conflict levels are in a two-way causal relationship. Models neglecting endogenous effects fall behind the basic tenet that poverty drives a cycle of violence, whereby poor societies fall into conflict and the conflict exacerbates the poverty (Gurr et al. 2001; Collier et al. 2003).

Lines of Future Work

A number of extensions may be considered depending on additional annual conflict data and updated poverty estimates.

With the data at hand (up to 2004), conflict rates can be analysed at the village and urban neighbourhood level (from which we aggregated them to the commune for this study). For models limited to rural communes, a wealth index may be constructed from asset estimates

(Filmer and Pritchett 2001). This approach would make use of the intra-commune variance. But these low-level units are not geo-referenced, and thus spatially structured terms would remain commune level contexts.

Working at the commune level, the common spatial component present in the three conflicts can be investigated with methods that go beyond the separate estimates in this study, and which have been advanced in joint disease mapping (Held et al. 2005). In models without the spatial term, over one-half of the variance in the residual rates of the three conflicts is shared; this justifies a joint analysis.

Assuming that SEILA will continue the conflict monitoring, new analytic opportunities will arise when commune-level poverty estimates are updated. The next population census is planned for 2008. Models of conflict rates would then be able to incorporate poverty change since 1998 as well as the conflict levels estimated for earlier years, with suitable attention to year-wise error components. This should make problems of endogeneity tractable.

With a promise of better reliability, and departing from the SEILA key informant format, conflict estimates might be produced from victimisation surveys at the household level. Victim data can be collected either through dedicated surveys or as part of living standards or health and demographic surveys, two long-standing international endeavours that would facilitate replication in other countries. The latest living standards survey in Cambodia took place in 2003–2004. Since these traditions have not emphasised community context and spatial modelling, quantities of interest from this SEILA data analysis could be added as commune level background variables.

Conclusion

Working with a narrow concept of human security, one that focusses, in the words of the UN Secretary General, on “the protection of communities and individuals from internal violence” (as quoted in Mack 2005, page v), this study harnesses data on different local conflicts to a theoretical model. Bayesian methods ensure at the same time that the associations between socio-economic variables and conflict rates are explored in flexible ways. Spatial models help control for measurement error and for the effects of unobserved variables. The results go beyond those of parametric models, notably in the identification of numerous non-linearities, but also in dissipating effects that had appeared significant, if implausible, under parametric assumptions.

Some covariates show distinct thresholds at which the effects on conflicts take off steeply. Most relevant for policy considerations are those that indicate quality of governance. Two findings stand out. Communities that enjoy intermediate levels of service provision tend to have higher levels of conflict than those barely provided for, suggesting interacting struggles for control of outside aid as well as of local resources, particularly land. Second, the thresholds to personal security are high. In 2002–2004, four-fifths of communes were below the range where our governance indicators are associated with significantly lower domestic violence and land conflict. This suggests that major threats such as homicide, rape and fights over land need to be reduced through dedicated interventions.

These findings have to be read with all the caveats due to cross-sectional analyses. The ongoing nature of the conflict monitoring and the next national population census, planned for 2008, should present opportunities for enhanced studies to address issues of mutual causation. This will help clarify the relationship between the narrowly defined personal security and wider concepts that include economic security. Flexible exploration using

Bayesian models and controlling for spatial and temporal dependencies will remain useful while research from other post-war contexts may contribute new analytic ideas.

Although entities in Cambodia were not the only sources of our data (the bombing data is from the United States government), their ability to observe conflicts and violence in over 13,000 local communities, and to measure a spectrum of socio-economic conditions at that or the next higher administrative units should in itself have a positive impact on human security. The range and scope of these monitoring efforts may have its roots in the United Nations administration of the country in the 1990s, but they are now woven into the national fabric through the government's large decentralisation programme.

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