Ethnic Polarization, Ethnic Salience, and Civil War

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Abstract

This article examines how the relationship between ethnic polarization and civil war could be moderated by different degrees of ethnic salience. We use an agent-based computational model to analyze the polarization-conflict relationship when ethnicity is "fixed"—salient for every member of two nominally rival ethnic groups—and when ethnic salience is "variable"—permitted to vary across individuals within groups as a function of relative income. Our results indicate that: (*i*) when ethnic salience is fixed, conflict onset is more than twice as high at low levels of polarization compared to when salience is permitted to vary, with the difference decreasing at high levels of polarization; (*ii*) the relationship between conflict onset and the per-capita range over which we calculate variable ethnic salience is positive and robust for low and moderate levels of ethnic polarization; (*iii*) the relationship between polarization and conflict onset is robust even under minority domination, if one holds ethnic salience fixed; and (*iv*) while the assumption of fixed ethnic salience effectively amplifies the negative effect of polarization on economic performance, economic policies may succeed or fail regardless of the level of ethnic polarization, their failure generating conflict over revenue sharing.

Introduction

How is the relationship between ethnic polarization and civil war moderated by different degrees of ethnic salience—the importance that individuals attach to ethnicity, one among several components of an identity repertoire? Measures of ethnic polarization—the probability that two randomly selected individuals will belong to different ethnic groups weighted by the relative size of each group—are commonly used to summarize the ethnic landscape of an entire country (Reynal-Querol 2002; Montalvo and Reynal-Querol 2005a, 2005b; Esteban and Ray 2008). The use of this summary statistic effectively assumes that ethnic salience is constant across individuals—that the depth of ethnic cleavages displays no spatial or temporal variation, independent of changes in the relative size of ethnic groups (Bossuroy 2006, Norris and Mattes 2003; Posner 2004b). Yet, empirical evidence would suggest otherwise.

A key question from rounds 1 and 2 of the Afrobarometer Survey—to our knowledge, the only individual-level, multi-country, multi-round survey of its kind in the African context—gauges the relative salience respondents attach to different group identities, one of which is ethnicity:[1]

> We have spoken to many [citizens of country name] and they have all described themselves in different ways. Some people describe themselves in terms of their language, ethnic group, religion, or gender, and others describe themselves in economic terms, such as working class, middle class, or a farmer. Besides being [nationality], which specific group do you feel you belong to first and foremost?[2]

Table 1 summarizes data from 25,544 respondents sampled across 8 countries for this question, and compares this data to each country's polarization score.[3] The survey data

indicate that: (*i*) there is considerable within-country variation in the share of respondents whose "first and foremost" identification lies with their ethnic group; (*ii*) in addition to within-country variance, there is also considerable cross-country variation in the share of respondents whose "first and foremost" identification lies with their ethnic group, ranging in round 1 from a high of 48% in Nigeria to lows of 13%, and 12% in Uganda and Zambia respectively; (*iii*) in comparing responses across rounds, the proportion of individuals who identify primarily with their ethnic group remains relatively stable in cases like Mali, Nigeria, and Zambia, whereas other cases display dramatic changes in ethnic salience, dropping in Zimbabwe from 47% to 13% and in Mali from 37% to 20%; and *(iv*) a significant gap exists between measures of ethnic salience, on the one hand, and measures of ethnic polarization and politically relevant ethnic groups on the other hand.

[Table 1 here]

Looking more specifically at the case of Nigeria, we disaggregate the 48% of respondents from round 1 who identified primarily with their ethnic group from the national to the state level. In the state of *Akwa Ibom*, located in southern Nigeria and comprised of 6 distinct but nonetheless related ethno-linguistic groups (the *Ibbibo, Annang, Oron, Ibeno, Eket,* and *Efik*), 93.6% of respondents identified primarily with their ethnic group. In *Abia*, another state in southern Nigeria inhabited by the Igbo, 86.3% of respondents identified primarily with their ethnic group. Clearly, the high level of salience attached to ethnicity in these states, as well as in the adjacent states of Bayelsa, Rivers, and Delta, is

partly due to their location in the contentious Niger Delta Region and the ongoing dispute over oil production and revenue. In marked contrast, a mere 16.3% of respondents in Katsina and 18.4% of respondents in Kano, northern states inhabited predominantly by the Hausa and Fulani, identified primarily with their ethnic group.

Like Nigeria, South Africa also displays within-country variation in ethnic salience: disaggregated along provincial lines, the percentage of round 1 respondents who identified primarily with their ethnic group varied from a low of 5.1% in the Northern Province (Limpopo), 7% in the Northern Cape, and 7.5% in the Western Cape (regions with the highest percentages of respondents identifying primarily with race) to a high of 30% in the Eastern Cape and 41.3% in Kwa-Zulu Natal. Unsurprisingly, the Cape was created in the post-apartheid era out of two "independent" homelands for the Xhosa, whereas Kwa-Zulu Natal combined the pre-1994 province of Natal and various parts of KwaZulu Bantustan, home to the Zulu monarch.[4] In South Africa, considerable cross-country variation in the aggregate share of respondents whose "first and foremost" identification lies with their ethnic group also exists across survey rounds, from 42% to 22% in rounds 1 and 2 respectively.

Taken together, the data support our claim that single summary statistics, like ethnic polarization, fail to effectively capture the heterogeneity of ethnic country-landscapes, papering over spatial and temporal variation in ethnic salience at the individual level.[5] Could the impact of ethnic polarization on the incidence of conflict then be more nuanced than posited by recent scholarship *if one relaxes the assumption that ethnic salience is*

fixed or invariant? In addressing this question, the ensuing theoretical analysis suggests that when permitted to vary, ethnic salience effectively moderates the relationship between ethnic polarization and civil war: that in comparison, levels of conflict onset are more than twice as high at low levels of polarization when salience is fixed; that the relationship between polarization and conflict onset is robust even under minority domination, if and only if one holds ethnic salience fixed; and our finding that the assumption of fixed ethnic salience effectively amplifies the negative effect of polarization on economic performance notwithstanding, economic policies may succeed or fail regardless of the level of ethnic polarization, their failure responsible for conflict over revenue sharing. These findings have a relatively straightforward, but nonetheless important, implication: if the importance individuals attach to their ethnic identities is a key determinant of conflict, then shifts in ethnic salience should assume center stage in explanations that link ethnicity to conflict.

Polarization and Conflict

Few scholars would venture so far as to argue that ethnicity is not an important factor in civil conflict. Yet, contrary to expectations, the bulk of the quantitatively oriented literature fails to establish a clear association between ethnicity and civil war, even in wars that are commonly identified as "ethnic" wars. Using the Ethno-Linguistic Fractionalization (ELF) Index, an aggregate measure of ethnic heterogeneity, these studies make one of the following arguments: (*i*) ethnic heterogeneity *decreases* the likelihood of civil war as coordination for rebellion becomes harder in more diverse societies (Collier and Hoeffler 2000); (*ii*) ethnic heterogeneity *increases* the likelihood of

internal armed conflict, and to a lesser degree of civil war (Sambanis 2004, Hegre and Sambanis 2006); (*iii*) ethnic heterogeneity *increases* the likelihood of civil war, yet the effect is *indirect* (Blimes 2006); (*iv*) consistent with Horowitz (1985), ethnic heterogeneity has a *non-monotonic* association with the outbreak of civil war (Elbadawi and Sambanis 2002)—low when the population is ethnically homogeneous and extremely diverse, and high when divided into a few prominent ethnic groups; or (*v*) ethnic heterogeneity has *no significant* relationship with the outbreak of civil war (Fearon and Laitin 2003; Fearon, Kasara and Laitin 2007).[6]

Given the rather ironic ``diversity'' of these findings, a wave of recent scholarship on the link between ethnicity and civil war specifies more robust indexes, most centering on measures of ethnic polarization. Montalvo and Reynal-Querol (2005a), for instance, attribute the absence of a statistically significant relationship between ethnic heterogeneity and the incidence of civil war specifically to the use of a fractionalization-index. As an alternative, they specify the RQ-Index of polarization and they find that the relationship between polarization and civil war is now robust. They also find that an increase in polarization has a negative but indirect effect on economic growth by increasing the incidence of conflict and consumption and lowering investment (Montalvo and Querol 2005b).[7]

Building upon this scholarship, Esteban and Ray (2008) find that measures of fractionalization and polarization tend to run in opposite directions: that conflict occurrence in polarized societies will be low whereas its intensity will be high, with the

relationship reversed for highly fractionalized societies. As such, Esteban and Ray suggest that the relationship between fractionalization and conflict is non-monotonic, and that a mirror-image inverted pattern defines the relationship between polarization and conflict.

Others explore variants of the polarization-conflict link: Østby (2008) examines whether various forms of polarization and horizontal inequalities affect the probability of civil conflict onset across 36 developing countries; Torenvlied and Haarhuis (2008) analyze the link between polarization and policy reform; Hegre (2008) applies Esteban & Ray's (1994) concept of polarization to two international distributions (world income distribution and the distribution of political systems) and investigates whether high levels of polarization are reflected in high conflict levels; while Forsberg (2008) analyzes the link between ethnic polarization and conflict in a widened strategic environment, encapsulating each state that experiences ethnic conflict and its neighboring state(s).[8]

Each of these studies significantly advances our understanding of the relationship between ethnic polarization on the one hand, and conflict on the other hand. Yet all either implicitly, or explicitly, assume that the distribution of individuals across ethnic groups determines the salience of ethnicity, or the weight that individuals place on ``ethnicity'' as a defining or core identity.[9] One consequence of this assumption is that absent a change in relative group sizes, ethnic salience remains constant across groups and, more notably, across individuals *within* ethnic groups. Thus, as the static (or exogenous) ELF index measuring ethno-linguistic diversity is replaced by the PREG index (Posner 2004a)

measuring politically relevant ethnic groups, the RQ-index of polarization to capture the intensity of potential conflict (Reynal-Querol 2002, Montalvo and Reynal-Querol 2005a), an index measuring the cultural (or linguistic) distance between groups (Fearon 2003), and an endogenously specified or dynamic fractionalization index (Campos and Kuzeyev 2007), key constructivist insights which suggest that the salience individuals attach to ethnicity—one of multiple identities individuals may possess—varies as a function of incentives or strategic manipulation (Chandra 2001, 2006) appear to have been buried, if not altogether discarded.[10]

Our Approach

Multivariate statistical models exploring the significance of key predictor variables on the incidence of civil war have established numerous empirical regularities, although these studies are constrained by the use of different datasets, variation in the operationalization and measurement of key variables (Hegre and Sambanis 2006, Ross 2006), and a limited ability to specify underlying causal mechanisms (Humphreys 2005) given: (*i*) the large number of relevant causal factors; (*ii*) complicated interactions between agents and associated factors; (*iii*) the difficulty of collecting useful data on agent characteristics and behavior; and (*iv*) a small set of ``natural experiments'' to test the effects of varying factors. Moreover, the very characteristics of *complex adaptive systems*—agent heterogeneity and adaptation, nonlinear mechanisms and feedback loops, non-random interaction topologies, and path dependent dynamics—violate many of the assumptions underpinning the use of traditional large-N approaches. In the absence of adequate tools

to deal with complex behavior, researchers are inclined to ignore these complexities, unnaturally limiting the scope of social research (Meyer et al., 2005).

In contrast to multivariate approaches, we view the onset of civil war as influenced by a set of processes which interconnect political, economic, and social factors—a prime example of a *complex adaptive system*, in which many decision-making agents, each with their own characteristics and behaviors, interact with and change both the physical environment and other agents, leading to nonlinear and path-dependent dynamics. Agent-based models or ABM (Bankes, 2002; Bonabeau, 2002; Conte et al., 1997) are well suited to meeting the challenge of modeling a *complex adaptive system* because they are formal, unambiguous, replicable and testable (Axelrod, 1997; Axelrod and Cohen, 2001)—lending themselves to study aspects of complex systems that are difficult to study using traditional analytic techniques (Parunak et al., 1998). ABMs therefore provide powerful ways to develop, evaluate, and test theories by undertaking complex though experiments that would be difficult to conduct in the real world.[11]

Given the limited availability of individual-level data on ethnic salience, as well as the gap between this data and aggregate national-level data on the incidence of civil war, we utilize an ABM to analyze how the effect of ethnic polarization on the incidence of civil war could be moderated by different degrees of ethnic salience at the individual level. In particular, we experiment with low and high levels of polarization, holding ethnic salience fixed at its maximum value. We then permit ethnic salience to vary across individuals as a function of relative group income, building on work which emphasizes

the materialist and instrumentalist basis of ethnicity (Bates 1974).[12] Next, we test the robustness of our results by analyzing intermediate levels of ethnic polarization, different ranges used to calculate relative income and determine ethnic salience, and the effect of minority domination. And finally, we analyze the effect of economic policy on conflict for different levels of ethnic polarization and different measures of ethnic salience.

The Computational Model

Our agent-based computational model is intrinsically a game between leaders of two nominally rival ethnic groups, one of which holds power and consequently serves as a target for takeover by the rival leadership. In contrast to a standard optimization problem in which a leader would maximize an objective function subject to constraints, we impose parameter values to define a leader's strategy set. We model, in other words, boundedly rational agents in a purposive effort to illustrate how sub-optimal spending and investment affect levels of conflict under different ethnic landscapes and a variety of natural resource regimes.

Conceptually, and at a higher level of abstraction, our model works as follows: at each timestep, rival leaders make spending and investment decisions; these decisions in turn generate revenue, affect territorial control and peasant support, and determine the emergence or progression of conflict which occurs when leaders seek to control the same cell(s); conflict, in turn, leads to new patterns of control over time. We consequently underscore the notion that patterns of spending and investment directly influence the instigation and spread of civil unrest by altering peasant support, the leadership's

capacity to control territory, and by implication, its ability to wage conflict.

Our computational model is best conceived of as an *exploratory* device, one that may be used to understand key causal drivers and mechanisms underpinning the incidence of civil war in artificial landscapes or specific real-world cases by permitting the user to select different degrees of ethnic salience, different patterns of ethnic polarization and domination, a variety of resource profiles and agent strategies. As such, users may conduct complicated thought experiments for which empirical data would, in most cases, be difficult if not impossible to collect. For example, those interested in the behavior of key agents could explore how a ruler's ability to generate revenue through the taxation or looting of natural resources affects the onset and duration of civil war; those interested in understanding the micro-foundations of recruitment could focus on the conditions under which the opportunity cost faced by peasants for joining a rebellion increase or decrease; while those interested in studying the effects of ethnicity on the incidence of civil war, as we are in this article, could formally study the consequences of different degrees of ethnic salience or different patterns of ethnic domination.

Figure 1 presents a summary of key model components, mechanisms, and feedback loops, explained formally in the Appendix (web-based) to this paper. To begin with, we define a *landscape* (component 1 in figure 1) as a discrete cellular grid with fixed borders and a capital city (C) located in the center. Each cell on the landscape may contain peasants from two rival *ethnic groups* (component 2)—the ethnic group in power or EGIP and the ethnic group out of power or EGOP. The landscape is characterized by

production which falls into one of four *economic sectors* (component 3). Economic policy, defined by the *sectoral* and *spatial spending decisions* (component 4) taken by leaders of each ethnic group, determines the amount of *revenue* (component 5) available to garner *peasant support* (component 6). Where such support is weak, peasants may relocate or *migrate* (component 7) to cells populated and controlled by members of their own ethnic group. Revenue is also used by leaders to *control territory* (component 8), and we underscore the importance of territorial control in this framework, given that control is a necessary condition for spending, investment, revenue generation, and popular support. All control is cell-specific, as is the breakdown of economic sectors, spending decisions, and peasant support. *Conflict* (component 9), also cell-specific, emerges when group leaders seek to control the same territory or cell.

[Figure 1 here]

Specific mechanisms linking revenue to conflict (*a-d* in Figure 1) include the following: (*a*) *robbery* leads to a decline in economic growth, undermining peasant support and weakening the state, making it more vulnerable to capture over time; (*b*) spending on *social welfare* increases popular support, but remains economically unviable in the long-term; (*c*) spending on coercive power alters peasant support and is essential for *territorial control*; and (*d*) investment in the economy, what we refer to as *benevolent rule* , increases the flow of revenue over time with a positive effect on peasant support. Key feedback loops (*i-n*) include the following: (*i*) changes in revenue (relative to the revenue of nominal rivals) increase (or decrease) the salience of ethnicity; (*j*) ethnic salience

affects peasant support; (*k*) high levels of peasant support decrease the cost of control, and control has a non-monotonic effect on support (excessive control lowers support, as does weak or insecure control); (*l*) when support for the leader in control of a cell is weak, peasants may exercise the option to migrate to ethnic enclaves in an effort to find safety in numbers; (*m*) migration changes the calculus of control, and thus affects spending, investment, and support for leaders;[13] (*n*) conflict, which arises when leaders seek to control the same territory, alters the control of individual cells and may ultimately alter control of the state.

Table 2 summarizes key model parameters and value ranges. As such, leaders of rival ethnic groups (*A* and *B*) may adopt one of four stylized economic policies: benevolent rule, robbery, social welfare, and territorial control; the *resource base* may vary from agriculture to one based on harder to extract kimberlite or artisanally extracted alluvial diamonds; peasants may belong to one of two nominally rival *ethnic groups*; *ethnic salience* may then be fixed or vary across individuals based on grievances that result from disparities in income; income disparities may, in turn, be calculated over different *per capita ranges*, beginning locally with an agent's own cell and increasing to cover the entire landscape; and finally, one may seed the model to capture different patterns of *ethnic polarization* and *ethnic domination*.

[Table 2 here]

We use the model to determine whether the relationship between ethnic polarization and civil war is moderated by different degrees of ethnic salience—the importance that individuals attach to ethnicity as one among a number of identities. Levels of ethnic polarization, measured with the RQ-index, are specified by varying the relative size of rival ethnic groups (see Table 3). Ethnic salience, in turn, is initially "fixed," following the primordial notion that ethnicity is always salient for all individuals. We then relax this assumption, permitting ethnic salience to vary across individuals as a function relative income, such that the greater the disparity between a peasant's per capita income and the income of nominal rivals, the greater the salience she attaches to her ethnicity.

[Table 3 here]

Experiments and Analysis

Experiments

We run four experiments using the computational framework described above. Our first experiment (A) tests the causal link between different levels of ethnic polarization, ethnic salience, and the incidence of civil war. Specifically, we examine how fixed (always salient) and variable (as a function of relative income) levels of ethnic salience moderate the influence of polarization on conflict, examining extreme cases in which the peasant population is evenly divided into two groups (n_A =0.50, n_B =0.50, RQ = 1) or into a dominant ethnic majority and a dominated ethnic minority (n_A=0.85, n_B=0.15, RQ=0.51), as well as intermediate levels of polarization (RQ=0.75, 0.89, 0.99). We record the incidence of civil war along the following dimensions: conflict onset—measured as the

percentage of cells on the landscape that experience at least one conflict; the number of conflict episodes—each episode defined by a lag of ten timesteps in which no conflict occurs in a cell; and conflict duration—measured in conflict-zones with a length and width of z grid cells. In subsequent experiments (B and C) we test the sensitivity of our results to variation in the ``per capita range'' over which ethnic salience is computed, and to a change in the structure of power relations between ethnic groups, by analyzing the effect of minority domination (e.g. for RQ=0.89, n_A =0.35, n_B=0.65). And in a final experiment (D), we examine the effect of economic policy on conflict by varying the strategy of the EGIP's leader from the default strategy robbery to benevolent rule, again under different levels of ethnic polarization and different measures of ethnic salience. Note that in all the experiments we analyze, default or baseline values for additional model parameters (expect when varied as part of the experiment) are as follows: the majority ethnic group A holds power; leaders of group A (B) play the robbery (benevolent) strategy; the resource base is alluvial; all calculations of relative income are made locally in the peasant's current cell (the per capita range is 0).[14] Our results are based on averages taken from 30 model runs with unique random seeds.

Analysis

Experiment A: Ethnic Polarization and Ethnic Salience. Results from experiment A, reported in Table 4, indicate that conflict onset is higher when ethnic salience is fixed (compared to when it is permitted to vary across individuals), as is the case with the number of conflict episodes. In particular, we find that conflict onset is 2.7 times higher under fixed relative to variable ethnic salience at the lowest level of ethnic polarization,

with the difference in onset under constant and variable salience decreasing to a factor 1.6 when polarization is at its maximal level. Specifically, when RQ=0.51, 14% of the landscape experiences at least one conflict when salience is fixed, whereas only 5% of the landscape experiences any conflict when salience is permitted to vary endogenously. And when RQ=1, 35% of the landscape experiences conflict under fixed salience, whereas 21% experiences conflict under variable ethnic salience.

In contrast, the difference in the number of conflict episodes under fixed and variable ethnic salience remains stable at both low and high levels of polarization (by a factor of approximately 1.4), whereas conflict duration is greater under variable ethnic salience when polarization is low, and only marginally higher under fixed ethnic salience when polarization is high. One explanation for the inverted result with conflict duration is that aggregate revenue is higher under variable ethnic salience (see Experiment D below), effectively allowing a greater share of resources to be devoted to coercive power, thereby prolonging conflict.

The trend in conflict onset at intermediate levels of polarization is generally consistent with what we observe at the extremes, as is the trend in conflict episodes and conflict duration. One exception occurs when the two groups are just shy of being equally sized. When RQ=0.99, conflict onset reaches a peak of 22% under variable ethnic salience, only marginally exceeding the level of conflict (21%) under maximal polarization when RQ=1. We observe a similar pattern in the number of conflict episodes which peak when RQ=0.99, and remain higher under variable ethnic salience from this point onward. And

finally, we note that conflict duration is greater under fixed ethnic salience once RQ ≥ 0.99.

[Table 4 here]

Experiment B: Ethnic Polarization, Ethnic Salience, and Per Capita Range. Experiment B tests how variation in the "per-capita range" over which variable ethnic salience is computed affects the incidence of conflict for different levels of ethnic polarization. Table 5 summarizes these results. When we increase the per-capita range—the spatial distance or radius used to make per-capita income comparisons between members of rival groups—from 0 (the single cell in which the peasant is located and the default value used in the experiments above) to 2, 5 (intermediate levels) and then 10 (the entire landscape), conflict onset consistently increases in so far as group A remains a clear majority. As members of the minority group compare their economic well-being with that of majority group members located in ever more distant parts of the landscape, ethnic salience and conflict increase. As the disparity in size between the minority and majority group narrows (RQ=0.99), however, the relationship between per-capita range and conflict onset changes direction. And once the two groups are equally sized (RQ=1), the relationship becomes less clear cut as the disparity between a peasant's local environment and the global environment (or entire landscape) increases significantly.

[Table 5 here]

Experiment C: Ethnic Polarization, Ethnic Salience, and Minority Domination. In a recent article, Cederman, and Girardin (2007) voice a concern that studies of ethnic and other civil wars pay scant attention to the effects of minority domination.[15] Wimmer, Cederman & Min (2007) also provide empirical support for the proposition that the exclusion of a large ethnic group from power, rather than ethnic diversity, better explains the outbreak of civil war. In sharp contrast to these studies, Fearon, Kasara, & Laitin (2007) find weak and region-specific empirical support for the argument that the exclusion of large groups from power increases the likelihood of civil conflict. We make a modest, albeit theoretical, contribution to this debate by running experiment D, in which we examine the sensitivity of our results to minority domination at different levels of polarization under fixed and variable measures of ethnic salience.

The results, reported in Table 6, indicate that minority domination does influence the incidence of conflict, and that the effect is sensitive to the specification of ethnic salience. When ethnic salience is fixed, conflict onset increases with the level of polarization or size of the minority in power, peaking when the groups are close but not yet equal in size (RQ=0.99). In marked contrast, when ethnic salience is permitted to vary, conflict onset decreases as the level of polarization rises, or as the size of the minority approaches that of the majority group. These findings imply that the relationship between polarization and conflict onset is robust even under minority domination *if one holds ethnic salience fixed*. That said, the effect of minority domination on the incidence of conflict is greatest precisely when the minority is small (relative to the majority), when polarization is low and when ethnic salience is permitted to vary.

Turning to the other measures of conflict, we find that the number of conflict episodes increases with the size of the minority in power and is greater when ethnic salience is permitted to vary. An exception occurs when RQ=0.99, from which point on the number of episodes under fixed salience exceeds that under variable salience. Conflict duration displays a trend similar to that reported in experiments A and B until RQ=0.89, after which duration declines under both fixed and variable ethnic salience becoming equivalent (RQ-0.99), and then increases moderately when the rivals groups are equally sized (RQ=1).

[Table 6 here]

Experiment D: Ethnic Polarization, Ethnic Salience, and Economic Policy. In our final experiment, we analyze the effect of a change in economic policy on conflict at different levels of polarization, under both fixed and variable measures of ethnic salience. Our findings are summarized in Table 7.

To begin with, we note that in all the cases examined in this experiment, total revenue is higher when ethnic salience varies, suggesting that the assumption of fixed ethnic salience effectively amplifies the negative (positive) effect of polarization on economic performance (conflict onset). Yet, even this effect is open to question.

At the minimal level of polarization (RQ=0.51), *benevolent rule*—a fiscally prudent strategy by which spending and investment are diversified across the economy without neglecting the military—generates no conflict (as expected) and yields high revenue, accrued exclusively by the EGIP's leadership $\dot{A}$. In contrast, our default and fiscally imprudent strategy *robbery* generates conflict (also as expected), with the lion's share of revenue still going to $\dot{A}$, and a proportional (relative to group size) share of revenue going to $\dot{A}$. At the maximal level of ethnic polarization (RQ=1), $\dot{A}$'s total revenue *increases* under *benevolent rule* (the rival ethnic group *B* is larger, poorer, and more of its members consequently seek to benefit economically under $\dot{A}$), whereas $\dot{A}$'s total revenue decreases under robbery with a greater share going to $\dot{B}$.

These findings suggest that the success or failure of economic policy generates conflict over revenue sharing, and that economic policy may succeed or fail regardless of the level of ethnic polarization.

[Table 7 here]

Conclusion

Do levels of ethnic polarization effectively explain the incidence of civil conflict? Our response to this question is a qualified ``yes'', given that our findings point to ethnic salience as a key moderating variable in the polarization-conflict relationship. Using an agent-based computational model, we examine how the effect of ethnic polarization on the incidence of civil war *could* be moderated by different degrees of ethnic salience.

First, we find that when ethnicity is ``fixed'' or assumed to be salient for all individuals across rival groups, conflict onset is more than twice as high at the lowest level of ethnic polarization (RQ=0.51), with the difference decreasing as polarization reaches its highest or maximal level (RQ=1). And while the disparity in conflict onset under fixed and variable ethnic salience holds across intermediate levels of polarization (RQ=0.75. 0.89. 0.99), we find little support for a non-monotonic relationship between ethnic polarization and conflict onset, in contrast to findings presented by Esteban and Ray (2008). Turning to the number of conflict episodes, we find a similar trend, albeit with the difference under fixed and variable ethnic salience remaining stable. Conflict duration, in contrast, is higher under variable ethnic salience at low and intermediate levels of polarization (RQ=0.51-0.89), with the result inverted at high levels of polarization (RQ=0.99-1).

Second, we find the relationship between conflict onset and the per-capita range over which variable ethnic salience is calculated to be positive and robust until RQ=0.89, beyond which the relationship is contingent upon the existence and distribution of localized ethnic enclaves on the model's landscape. Our findings also indicate that minority domination *could* influence the incidence of conflict, and that the effect is sensitive to the specification of ethnic salience: when ethnic salience is fixed, conflict onset increases with the level of polarization or size of the minority in power, peaking when the groups are close but not yet equal in size (RQ=0.99); when ethnic salience is permitted to vary, however, conflict onset decreases as the level of polarization rises. This finding effectively suggests that the relationship between polarization and conflict

onset could be robust even under minority domination, if and only if one holds ethnic salience constant. In addition, we find that the number of conflict episodes is likely to be greater under variable ethnic salience when minorities hold power, although this effect diminishes in magnitude and is then reversed as the rival groups approach parity.

And finally, our last experiment indicates that increasing polarization to its maximal level has a negative effect on economic performance *under specific economic polices* (i.e. robbery), with the effect amplified by the assumption of fixed ethnic salience. Given empirical evidence supporting the finding that a maximal level of polarization is negatively correlated with lower growth rates (Easterly and Levine 1997) and lower levels of participation in groups and associations (Alesina and La Ferrara, 2000), it may be reasonable to posit that robbery (or other strategies that effectively generate this negative correlation) are more likely to be observed in the real world. That said, we find that under other economic policies (i.e. benevolent rule) increasing polarization to its maximal level has a positive effect on economic performance, leading us to conclude that while economic policy may succeed or fail regardless of the level of ethnic polarization, it is policy failure that generates conflict over revenue sharing. Thus, in contrast to the assertion that ethnic polarization has an indirect negative effect on growth because of the increased conflict risk and concomitant reduction in investment (Montalvo and Querol 2005b), the causal arrow *could* run directly from economic policy to performance and conflict, with resulting conflict levels then moderated by ethnic polarization.

Our theoretical analysis has a significant, if relatively straightforward, implication for research on ethnicity and civil war: if indeed the importance individuals attach to their ethnic identities is a key determinant of conflict, then shifts in ethnic salience should assume center stage in explanations that link ethnicity to conflict. We therefore close with a call for scholars to find new and novel ways to bridge the gap between individual-level data on ethnic salience and aggregate data on conflict onset, episodes, and duration. Recent work by Raleigh and Hegre (2005), Buhaug and Rød (2006), Cederman, Rød, & Weidmann (2006), Dorussen (2007), and Weidmann (2007) disaggregating civil conflict to the sub-national level constitutes a promising start in this direction.

Notes

[1] See Bratton, Mattes, and Gyimah-Boadi (2004) for details about the Afrobarometer project.

[2] Other identity categories for this question include religion, occupation/class, and gender. See Eifert, Miguel, and Posner, (2007) for a detailed discussion of the limitations associated with the use of this question to measure ethnic salience, including but not limited to issues related to the context specificity of respondent answers, idiosyncratic situational factors, the bias associated with self-reported identities, and the fact that the survey question explicitly bars respondents from describing themselves primarily in terms of their national identity, and the generalizability of the sample to the broader African context. Note also that the question we use was dropped from round 3 of the Survey.

[3] The country index scores were taken from Montalvo and Reynal-Querol (2005).

[4] Nigeria and South Africa were not alone in this respect, with ethnic salience varying from lows of 11.1- pt highs of 68.4% across 8 regions including the capital district in Mali, from 12.5-84.4% across 15 districts in Malawi, and from 26.2-77.1% across 10 provinces in Zimbabwe.

[5] Our analysis raises the question of whether an individual-level approach is useful for explaining group behavior? Our response is emphatically affirmative: (*i*) groups are not monolithic in their propensity to engage in violence against nominal rivals; (*ii*) groups are comprised of heterogeneous individuals who vary in their antipathy towards rivals, as well as in their willingness to bear the (high and often prohibitive) costs associated with violent behavior; (*iii*) group membership need not, therefore, determine the strength of individual attachment to ethnicity. That said, groups remain important in determining power relations, which in turn shape individual behavior. As a result, our framework captures both group (ethnic domination and polarization) and individual-level (ethnic salience) attributes associated with ethnicity.

[6] The ELF measures the likelihood that two people chosen at random will not belong to the same ethnic group. Compiled by a team of Soviet ethnographers in the early 1960s, the ELF is calculated using the Herfindahl concentration formula: $ELF = 1 - \sum_{i=1}^{n} s_i^2$ where s_i is the share if group $i (i = 1,....,n)$.

[7] More recently, Campos and Kuzeyev (2007) use census data from 26 former communist countries undergoing transitions to introduce time-sensitive fractionalization indices in an effort to endogenize the relationship between ethnic heterogeneity and growth (Alesina and La Ferrara 2005; Posner 2005). They find that when treated exogenously, ethnic fractionalization has little or no impact on economic growth. Treated endogenously, however, fractionalization is negatively related to growth and the finding is robust to the use of different specifications of ethnic fractionalization and polarization.

[8] Schneider and Wiesehomeier (2006) take exception to findings that support the polarization-conflict link, arguing instead that highly-polarized countries are no more likely to experience civil war than countries characterized by low levels of ethnic polarization, and suggesting that fractionalization not polarization is negatively associated with economic growth. Their argument centers on the coding and classification of conflict, highlighting the distinction between conflict incidence and conflict onset.

[9] For example, Esteban and Ray use a measure of polarization $P(\sigma, b) = \sum_i \sum_{j+1} n_i^{1+\sigma} n_j b_{ij}$ where b is the matrix of intergroup distances or alienation with respect to other groups, and σ captures the extent of intergroup identification or group size. They reduce this equation to $P = \sum_i n_i^2 (1 - n_i)$, or the RQ-Index of polarization, based on the assumptions that individuals in each group feel equally alien towards all groups but their own $(b_{ij} = b_i \quad \forall \quad i \neq j)$ and $\sigma = 1$ and $b_i = 1$.

[10] Posner acknowledges that this criticism is equally applicable to the PREG index which he introduces as an alternative to the ELF, noting that the PREG index takes no explicit account of either the degree of concentration of the ethnic groups in the country or the depth of the divisions among them (2004, 855).

[11] See Lim, Metzler, and Bar-Yam (LMB) for a recent analysis that utilizes ABM to study ethnic violence. Despite some general similarities between the LMB and our own framework (landscape comprised of grid cells, agents who migrate, ethnic/civil violence as an explanatory variable), the most notable departure lies in the LMB assumption that violence arises due to the structure of boundaries between ethnic groups, rather than inherent conflicts between groups themselves—that the spatial population structure, as opposed to measures of ethnic diversity such as fragmentation, increases the propensity for violence. Underlying this assumption is the notion that spatial heterogeneity *itself* serves as a predictor of violence; that modeling violence at the individual level is both unnecessary and impractical.

[12] For a complete description of our framework, entitled REsCape, see Bhavnani, Miodownik, and Nart (2008).

[13] In contrast to Lim, Metzler, and Bar-Yam's (2007) assumption that both highly mixed regions and well-segregated do not engage in violence, our framework permits us to analyze the *conditions under which* nominal ethnic rivals form ethnic enclaves, and whether the resulting ethnic segregation prevents violence.

[14] See Bhavnani, Nart, and Riolo (2008) for work that analyzes the effect of changes in resource regimes and strategy on the incidence of civil conflict.

[15] Cederman and Girardin (2007) introduce the *N** index in an effort to capture power relations between the government or ethnic group in power (EGIP) and peripheral ethnic groups out of power (EGOPs).

References

Alesina, Alberto, and Eliana La Ferrara. 2005. Ethnic Diversity and Economic Performance. *Journal of Economic Literature* 43(3): 762-800.

Axelrod, Robert. 1997. Advancing the Art of Simulation in the Social Sciences. In *Simulating Social Phenomena (Lecture Notes in Economics and Mathematical Systems)*, edited by Rosia Conte, Rainer Hegselmann, and Pietro Terna. Berlin: Springer-Verlag.

Axelrod, Robert and Michael Cohen. 2001. *Harnessing Complexity: Organizational Implications of a Scientific Frontier.* Chicago: The Free Press.

Bankes, Steven. 2002. Tools and Techniques for Developing Policies for Complex and Uncertain Systems. *Proceedings of the National Academy of Sciences of the United States of America* 99: 7263–7266.

Bates, Robert. 1974. Ethnic Competition and Modernization in Contemporary Africa. *Comparative Political Studies* 6 (4): 457-484.

Bhavnani, Ravi, Dan Miodownik, and Jonas Nart. 2008. REsCape: An Agent-Based Framework for Modeling Resources, Ethnicity, and Conflict. *Journal of Artificial Societies and Social Simulation* 11:2.

Bhavnani, Ravi, Jonas Nart, and Rick Riolo. (2008) Adaptive Agents, Natural Resources, and Civil War. Unpublished Manuscript.

Bonabeau, Eric. 2002. Agent-Based Modeling: Methods and Techniques for Simulating Human Systems. *Proceedings of the National Academy of Sciences of the United States of America* 99: 7280–7287.

Bossuroy, Thomas. 2006. Determinants of Ethnic Identification in West Africa. *Unpublished Working Paper.*

Bratton, Michael, Robert Mattes, and E. Gyimah-Boadi. 2004. *Public Opinion, Democracy and Market Reform in Africa* Cambridge: Cambridge University Press.

Blimes, Randall J. 2006. The Indirect Effect of Ethnic Heterogeneity on the Likelihood of Civil War Onset. *Journal of Conflict Resolution* 50 (4): 536-547.

Buhaug, Halvard, and Scott Gates. 2002. The Geography of Civil War. *Journal of Peace Research* 39 (4): 417–433.

Buhaug, Halvard, and Jan Ketil Rød. 2006. Local Determinants of African Civil Wars, 1970–2001. *Political Geography* 25 (3): 315–335.

Campos, Nauro, and Vitaliy Kuzeyev. 2007. On the Dynamics of Ethnic Fractionalization. *American Journal of Political Science* 51 (3): 620-639.

Cederman, Lars-Erik. 2004. Articulating the Geo-Cultural Logic of Nationalist Insurgency. Technical Report, ETH Center for Comparative and International Studies, Zurich, Switzerland.

Cederman, Lars-Erik, and Luc Girardin. 2007. Beyond Fractionalization: Mapping Ethnicity onto Nationalist Insurgencies. *American Political Science Review* 101 (1): 173-185.

Cederman, Lars-Erik, Jan Ketil Rød, and Nils B. Weidmann. 2006. Geo-Referencing of Ethnic Groups: Creating a New Dataset. Prepared presented at the *GROW Workshop*, Peace Research Institute Oslo (PRIO), February 10-11, 2006.

Chandra, Kanchan. 2001. Symposium: Cumulative Findings in the Study of Ethnic Politics. *APSA-CP Newsletter* (Winter): 7-11.

Chandra, Kanchan. 2006. What is Ethnic Identity and Does It Matter? *Annual Review of Political Science* 9:397-424.

Collier, Paul, and Anke Hoeffler. 2000. Greed and Grievance in Civil War. *World Bank Policy Research Working Paper* 2355, World Bank.

Conte, Rosia, Rainer Hegselmann, and Pietro Terna. (eds) . 1997. *Simulating Social Phenomena (Lecture Notes in Economics and Mathematical Systems)*, Berlin: Springer-Verlag.

Doyle, Michael, and Nicholas Sambanis. 2000. International Peacebuilding: A Theoretical and Quantitative Analysis. *American Political Science Review* 94 (4) : 779–801.

Dorussen, Han. 2007. Introducing PKOLED: A Peacekeeping Operations Location and Event Dataset.Paper presented at the conference on *Disaggregating the Study of Civil War and Transnational Violence*, University of Essex, November 24-25.

Elbadawi, Ibrahim, and Nicholas Sambanis. 2002. How Much War Will We See? Explaining the Prevalence of Civil War. *Journal of Conflict Resolution* 46 (3): 307–334.

Eifert, Ben, Miguel Edward, and Daniel N. Posner. 2007. Political Sources of Ethnic Identification. Paper presented at the conference on *Micro-foundations and Mass Politics in Africa*, Michigan State University, 12-13 May.

Esteban, Joan, and Debraj Ray. 2008. Polarization, Fractionalization and Conflict. *Journal of Peace Research* 45 (2): 163-182.

Fearon, James, and David Laitin. 2003. Ethnicity, Insurgency, and Civil War. *American Political Science Review* 97 (1): 75–90.

Fearon, James, Kimuli Kasara, and David Laitin. 2007. Ethnic Minority Rule and Civil War Onset. *American Political Science Review* 101 (1): 187-193.

Gates, Scott. 2002. Recruitment and Allegiance: The Microfoundations of Rebellion. *Journal of Conflict Resolution* 46 (1) :111–130.

Hegre, Håvard. 2002. Some Social Requisites of a Democratic Civil Peace: Democracy, Development, and Armed Conflict. Paper presented to the *Annual Meeting of the American Political Science Association*, Boston, MA, 29 August-1 September.

Hegre, Håvard, and Nicholas Sambanis. 2006. Sensitivity Analysis of the Empirical Literature on Civil War Onset. *Journal of Conflict Resolution* 50 (4): 508–535.

Horowitz, Donald. 1985. *Ethnic Groups in Conflict*, Berkeley: University of California Press.

Humphreys, Macartan. 2005. Natural Resources, Conflict, and Conflict Resolution: Uncovering the Mechanisms. *Journal of Conflict Resolution*, 49 (4): 508–537.

Lim, Metzler, and Bar-Yam. 2007. Global Pattern Formation and Ethnic/Cultural Violence. *Science* 317 (5844): 1540-1544.

Lujala, Päivi, UJALA P, Nils Petter Gleditsch, and Elisabeth Gilmore. 2005. A Diamond Curse?: Civil War and a Lootable Resource. *Journal of Conflict Resolution* 49 (4): 538–562.

Lustick, Ian S., and Dan Miodownik. Forthcoming. Abstractions, Ensembles, and Virtualizations: Simplicity and Complexity in Agent-Based Modeling. *Comparative Politics*.

Meyer, Alan D., Vibha Gaba, and Kenneth A. Colwell. 2005. Organizing Far from Equilibrium: Non-Linear Change in Organizational Fields. *Organization Science* 16 (5): 456-473.

Montalvo, José G., and Marta Reynal-Querol. 2005a. Ethnic Polarization, Potential Conflict, and Civil Wars. *The American Economic Review* 95 (3): 796-816.

Montalvo, José G., and Marta Reynal-Querol. 2005b. Fractionalization, Polarization, and Economic Development. *Journal of Development Economics* 76 (2): 293-323.

Norris, Pippa, and Robert Mattes. 2003. Does Ethnicity Determine Support for the Governing Party? *KSG Working Paper Series No. RWP03-009*.

Østby Gudran. 2008. Polarization, Horizontal Inequalities and Violent Civil Conflict. *Journal of Peace Research* 45 (2): 143-162.

Parunak, Van Dyke, Robert Savit, and Rick Riolo. 1998. Agent-Based Modeling vs. Equation-Based Modeling: A Case Study and Users' Guide. In *Workshop on Multi-Agent Systems and Agent-Based Simulation*, Springer: 10–25.

Posner, Daniel. 2004a. Measuring Ethnic Fractionalization in Africa. *American Journal of Political Science* 48 (4): 849-863.

Posner, Daniel. 2004b The Political Salience of Cultural Difference: Why Chewas and Tumbukas are Allies in Zambia and Adversaries in Malawi? *American Political Science Review* 98 (4): 529-545.

Posner, Daniel. 2005. *Institutions and Ethnic Politics in Afric*a, MA: Cambridge University Press.

Raleigh, Clionadh, and Håvard Hegre. 2005. Introducing ACLED: An Armed Conflict Location adn Even Dataset. Paper presented at conference on *Disaggregating the Study of Civil War and Transnational Violence*, University of California, Institute of Global Conflict and Cooperation, San Diego, CA, 7–8 March.

Reynal-Querol, Marta. 2002. Ethnicity, Political Systems, and Civil Wars. *Journal of Conflict Resolution* 46 (1): 29–54.

Ross, Michael. 2006. A Closer Look at Oil, Diamonds, and Civil War. *Annual Review of Political Science* 9: 265-300.

Sambanis, Nicholas. 2001. Do Ethnic and Nonethnic Civil Wars Have the Same Causes? A Theoretical and Empirical Inquiry (Part 1). *Journal of Conflict Resolution* 45 (3): 259–282.

Sambanis, Nicholas. 2004. What is Civil War? Conceptual and Empirical Complexities of an Operational Definition. *Journal of Conflict Resolution* 48 (6): 814-858.

Schneider, Gerald & Nina Wiesehomeier, 2006. Ethnic Polarization, Potential Conflict, and Civil Wars: Comment. Unpublished Manuscript, University of Konstanz.

Synder, Richard, and Ravi Bhavnani. 2005. Blood, Diamonds, and Taxes: Lootable Wealth and Political Order in Sub-Saharan Africa. *Journal of Conflict Resolution* 49 (4): 563–597.

Weidmann, Nils. 2007. Geographic Group Fragmentation and Civil Peace. Paper presented at conference on *Disaggregating the Study of Civil War and Transnational Violence*, University of Essex, November 24-25.

Wimmer, Andreas, Lars-Erik Cederman, and Brian Min. 2007. Ethnic Politics and Violent Conflicts, 1946-2005: A Configurational Approach. Paper presented at the conference *Disaggregating the Study of Civil War and Transnational Violenc*e, University of Essex, 24-25 November 2007.

Table 1. Afrobarometer Data on Ethnic Salience

Country	*RQ-Index*	*PREG*	*Ethnic Salience* Round 1 (*N*)	*Ethnic Salience* Round 2 (*N*)
South Africa	0.72	0.49	0.42 (2200)	0.22 (1200)
Zimbabwe	0.7	0.41	0.47 (1200)	0.13 (1200)
Malawi	0.74	0.55	0.37 (1208)	0.20 (1200)
Zambia	0.61	0.71	0.12 (1198)	0.11 (1201)
Mali	0.42	0.13	0.40 (2089)	0.37 (1200)
Nigeria	0.4	0.66	0.48 (3603)	0.47 (1200)
Uganda	0.28	0.63	0.13 (2271)	0.19 (1200)
Tanzania	0.27	0.59	0.03 (2198)	0.18 (1200)

Source: Measures of *Ethnic Salience* obtained from Afrobarometer Surveys Round 1 (1999-2001) and Round 2 (2002-2004); *RQ* scores obtained from Montalvo and Reynal-Querol 2005a; *PREG* scores obtained from Posner 2004a. *Note*: *N* denotes the total number of respondents per country. Namibia was omitted from the analysis because of missing *RQ* values. Lesotho was omitted due to small sample size, whereas the question of interest was not asked in Ghana. Round 3 data were not included for the same reason. Botswana was dropped due to the absence of meaningful ethnic cleavages.

Table 2. Summary of Model Parameters and Settings

Parameter Name	*Parameter Settings*			
Economic Policy $^{\dot{A},\dot{B}}$	benevolent rule	robbery	social welfare	territorial control
Resource Base	agriculture	kimberlite	alluvial industrial	alluvial artisanal
Resource Location	diffuse	point source		
Ethnic Group	A	B		
Ethnic Salience	fixed	variable		
Per Capita Range	single cell	entire landscape		
Ethnic Polarization	high	low		
Ethnic Dominance	majority rule	contest power	minority rule	

Note: Per Capita Range and Polarization are both specified as continuous variables.

Table 3. Polarization, Group Size, and the RQ Index

Polarization	*Relative Size of Rival Ethnic Groups*	$RQ = 4\sum_{i=1}^{N}\pi_i^2(1-\pi_i)$
low	n_A =0.85, n_B =0.15	0.51
moderate	n_A =0.75, n_B =0.25	0.75
	n_A =0.65, n_B =0.35	0.89
high	n_A =0.55, n_B =0.45	0.99
	n_A =0.50, n_B =0.50	1

Table 4. Polarization and Salience

Polarization	*Ethnic Salience*	*Conflict*		
		Onset (s.d)	Episodes (s.d)	Duration (s.d)
RQ=0.51	fixed	0.14 (0.01)	166.97 (23.56)	7.48 (1.10)
RQ=0.51	variable	0.05 (0.01)	112.03 (19.33)	10.16 (1.10)
RQ=0.75	fixed	0.23 (0.02)	195.50 (35.29)	6.93 (1.08)
RQ=0.75	variable	0.11 (0.02)	130.40 (18.99)	9.54 (1.19)
RQ=0.89	fixed	0.29 (0.02)	435.13 (36.57)	11.84 (0.91)
RQ=0.89	variable	0.16 (0.02)	358.00 (36.21)	15.02 (2.58)
RQ=0.99	fixed	0.31 (0.03)	461.33 (65.35)	13.60 (1.96)
RQ=0.99	variable	0.22 (0.02)	521.87 (60.47)	11.59 (2.56)
RQ=1	fixed	0.35 (0.05)	610.47 (134.09)	16.84 (1.90)
RQ=1	variable	0.21 (0.02)	433.20 (59.83)	16.67 (2.43)

Table 5. Polarization, Salience, and Per Capita Range

Polarization	*Ethnic Salience*	*Per Capita Range*	*Conflict*		
			Onset (s.d)	Episodes (s.d)	Duration (s.d)
RQ=0.51	variable	2	0.08 (0.01)	88.17 (23.53)	7.37 (1.39)
RQ=0.51	variable	5	0.09 (0.02)	58.93 (117.53)	4.81 (1.27)
RQ=0.51	variable	10	0.09 (0.02)	61.47 (18.79)	6.00 (1.73)
RQ=0.75	variable	2	0.18 (0.02)	315.70 (63.48)	8.21 (2.30)
RQ=0.75	variable	5	0.20 (0.02)	309.47 (30.33)	10.16 (0.97)
RQ=0.75	variable	10	0.20 (0.02)	322.17 (49.73)	9.31 (1.45)
RQ=0.89	variable	2	0.17 (0.021)	370.83 (10.93)	10.93 (1.61)
RQ=0.89	variable	5	0.23 (0.022)	423.97 (44.04)	10.80 (1.15)
RQ=0.89	variable	10	0.24 (0.01)	428.23 (40.69)	10.86 (0.81)
RQ=0.99	variable	2	0.22 (0.01)	511.60 (39.59)	10.57 (1.24)
RQ=0.99	variable	5	0.20 (0.01)	480.37 (33.70)	11.32 (0.70)
RQ=0.99	variable	10	0.17 (0.02)	281.60 (29.02)	15.69 (1.33)
RQ=1	variable	2	0.20 (0.02)	406.23 (21.59)	15.28 (1.12)
RQ=1	variable	5	0.25 (0.02)	482.00 (61.85)	15.07 (2.09)
RQ=1	variable	10	0.22 (0.00)	509.20 (16.98)	11.10 (0.98)

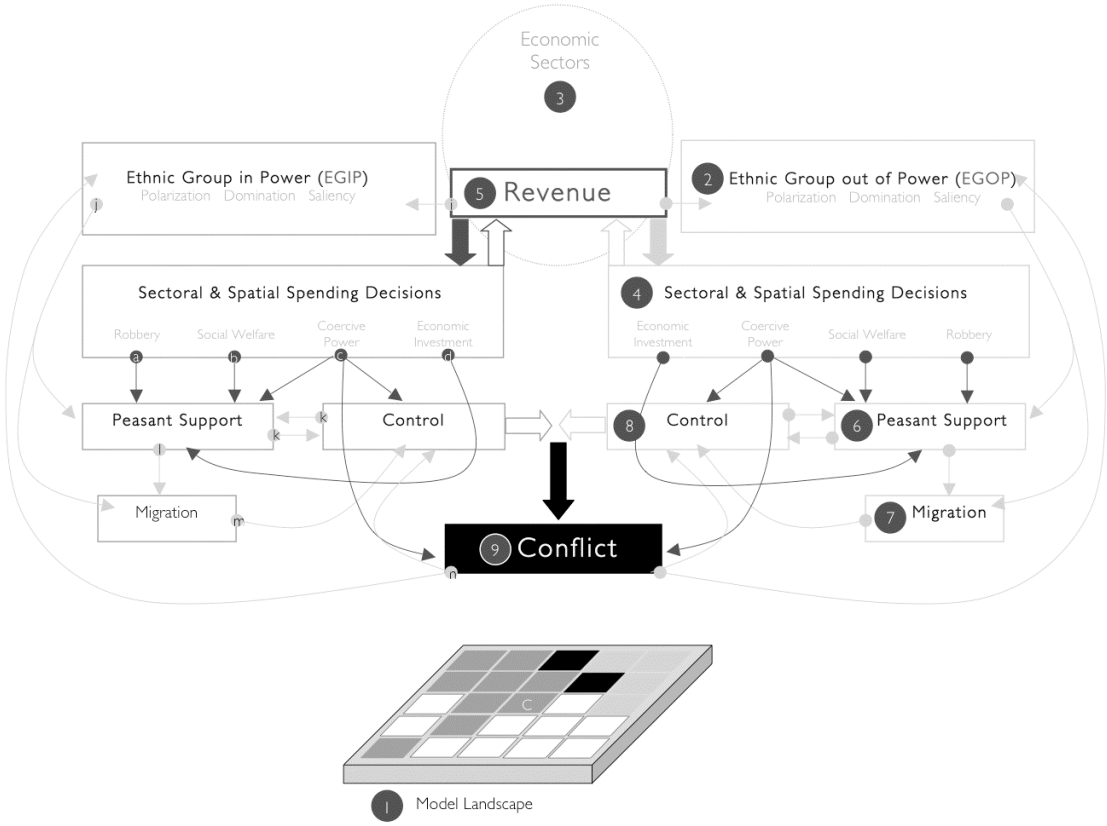
Table 6. Polarization, Salience, and Minority Domination

Polarization	*Size of Group A*	*Ethnic Salience*	*Conflict*		
			Onset (s.d)	Episodes (s.d)	Duration (s.d)
RQ=0.51	n_A =0.15	fixed	0.25 (0.01)	175.83 (11.49)	7.35 (1.04)
RQ=0.51	n_A =0.15	variable	0.34 (0.00)	182.00 (0.00)	13.74 (0.00)
RQ=0.75	n_A =0.25	fixed	0.26 (0.02)	213.83 (37.33)	11.23 (1.41)
RQ=0.75	n_A =0.25	variable	0.27 (0.01)	315.13 (9.47)	13.95 (2.27)
RQ=0.89	n_A =0.35	fixed	0.28 (0.01)	356.63 (66.02)	15.26 (1.35)
RQ=0.89	n_A =0.35	variable	0.27 (0.02)	371.23 (70.29)	19.34 (1.63)
RQ=0.99	n_A =0.45	fixed	0.38 (0.03)	447.03 (166.34)	15.01 (2.10)
RQ=0.99	n_A =0.45	variable	0.22 (0.03)	441.23 (84.91)	15.50 (3.25)
RQ=1	n_A =0.50	fixed	0.35 (0.047)	610.47 (134.09)	16.84 (1.91)
RQ=1	n_A =0.50	variable	0.21 (0.017)	433.20 (59.83)	16.67 (2.43)

Table 7. Polarization, Salience, and Economy Policy

Polarization	*Policy*	*Ethnic Salience*	*Revenue*		*Conflict*
			$\dot{A}$ (s.d)	$\dot{B}$ (s.d)	Onset (s.d)
RQ=0.51	Benevolent	fixed	943.88 (0.00)	0	0
	Benevolent	variable	995.26 (0.00)	0	0
RQ=0.51	Robbery	fixed	854.79 (29.41)	139.56 (9.21)	0.14 (0.01)
	Robbery	variable	925.71 (40.78)	139.78 (10.29)	0.050 (0.01)
RQ=1	Benevolent	fixed	1006.52 (0.00)	0	0
	Benevolent	variable	1056.47 (0.00)	0	0
RQ=1	Robbery	fixed	419.60 (129.98)	522.08 (117.22)	0.35 (0.047)
	Robbery	variable	504.28 (174.69)	532.66 (118.12)	0.21 (0.017)

Figure 1. Key Components, Mechanisms, and Feedback Loops



Ethnic Polarization, Ethnic Salience, and Civil War

Appendix

We begin by describing the sequence of model steps, followed by a description of model components related to ethnicity—polarization, domination, and salience. Next we describe the model's economy—investment, revenue, spending, and support—and conclude with a description of components related to civil war—coercive power, control, and conflict.

Sequence of Model Steps

We describe the basic sequence of model steps below:

- Determine the degree of ethnic polarization by specifying the population share of two rival ethnic groups
- Determine the structure of ethnic domination by specifying the EGIP and by default the EGOP
- Determine whether ethnic salience is fixed or variable
    - In each timestep of a model run:
        - Leaders of each ethnic group make sectoral and spatial spending decisions
        - Spending decisions generate revenue for leaders and peasants
            - Future spending and investment is, in turn, constrained by revenue
            - Peasant's determine their level of support for leaders as a function of revenue, security, and ethnicity
            - If support is low, peasants migrate to ethnic enclaves
        - Migration alters the calculus of control
    - Conflict emerges when group leaders seek to control the same cell
        - Conflict determines new patterns of territorial control
        - Change in control of the capital city effectively changes the EGIP

Ethnicity: Polarization, Domination, and Salience

We specify different degrees of ethnic *polarization* varying the relative size of rival ethnic groups and different patterns of ethnic *domination* by specifying the EGIP. We also specify different levels of ethnic *salience*, first by assuming that ethnicity is salient for all individuals or constant across all groups, and next by permitting ethnic salience to vary across individuals as a function relative income. Specifically, all agents carry an ethnic marker identifying them as members of an ethnic group *A* or *B*. Ethnic salience e denotes the significance of ethnicity to a peasant, and may either be fixed ($e_i^A = e_i^B = 1$) for all peasants or vary across peasants ($e_i^A, e_i^B, \in [0,1]$). In the latter case, we specify ethnic salience as a function of relative revenue: the greater the disparity between a peasant's per capita income and the income of nominal rivals, the greater the salience attached to her ethnicity.

Let *N* equal the total population and let n_A denote the proportion of peasants from group *A*, the n_B proportion from group *B*. Per capita income for members of group *A* is then defined by $y_{pc}^{A,r} = \frac{\sum y^A}{n_A \cdot N}$, where *r* denotes the range over which per capita income is calculated, what we refer to as the "per-capita range", which can vary from 0 (only the current cell in which the peasant is located) to 10 (the entire landscape), permitting peasants to make "local" or myopic calculations, or by contrast, calculations based on "global" information. By a similar logic per capita income for group *B* is given by $y_{pc}^{B,r} = \frac{\sum y^B}{n_B \cdot N}$. Ethnicity becomes salient when a peasant's per capita income is smaller than the per-capita income of nominal rivals. It follows that for a member of group *A*, ethnic salience is give by $e_i^A = \frac{y_{pc}^B - y_i^A}{y_{pc}^B}$, and by the same logic, the salience of ethnicity *B* would given by $e_i^B = \frac{y_{pc}^A - y_i^B}{y_{pc}^A}$.

The Economy: Revenue and Spending

We define a *landscape* as a discrete cellular grid with fixed borders, and a capital city located in the center. We note that the size and the shape of this grid is alterable by the user. In the current specification, each of the 441 (21x21) cells may contain any number of agents, divided into members (peasants) and leaders $\dot{A}$, $\dot{B}$ of the two rival *ethnic groups A* and *B*. Each cell on the model's landscape may host one of four productive sectors: agriculture *ag*; artisanal

alluvial diamonds *aa*; industrial alluvial diamonds *ai*; and industrial kimberlite diamonds *ki*. $\dot{A}$, $\dot{B}$ decide how much to invest in each cell under their control, with investment raising the amount of extractable revenue in the short-run and increasing overall productivity and revenue in the medium to long run. We define investment $\bar{i}$:

$$\bar{i}(t+1) = \bar{i}(t) - \delta\,\bar{i}(t) + i(t),$$

with sector-specific depreciation rates $\delta_{ki}, \delta_{ai}, \delta_{aa}$ and $\delta_{ag} \leq 1$ such that every investment $\bar{i}_0$ decays exponentially:

$$\bar{i}(t) = \bar{i}_0 \exp^{-\delta t}$$

Note that investment in the industrial production is constrained by an upper limit $\bar{i}_{\max}$, such that $\bar{i}_{ki,\max} = \mu_{ki,\max} * k$ and $\bar{i}_{ai,\max} = \mu_{ai,\max} * a$ (where k and a respectively denote the size of kimberlite and alluvial deposits in a cell), and that a minimal level of investment $\bar{i}_{ki,\min} = \mu_{ki,\min} * k$, $\bar{i}_{ai,\min} = \mu_{ai,\min} * a$ is required to generate revenue. We assume that minimum and maximum investment for the extraction of kimberlite diamonds exceeds that for alluvial diamonds, or $\mu_{ki,\max} > \mu_{ai,\max}$ and $\mu_{ki,\min} > \mu_{ai,\min}$, and that investment in industrial diamond production is limited to the $\dot{A}$ although $\dot{B}$ can profit from previous government investment when they assume control of a cell. Note also that investment in artisanal and agricultural production is not bounded and does not require a minimum level to generate revenue.

Revenue *y* generated by each sector *x* in a grid cell is allocated to the actor in control of the cell $y_x^{(\dot{A},\dot{B})}$ and the peasants in the cell y_x^p in the following manner:

$$y_x^{(\dot{A},\dot{B})} = s_x \cdot y_x$$
$$y_x^p = (1 - s_x) \cdot y_x$$

Where $s_x \in [0,1]$ denotes the share of revenue going to the controlling agent. Specifically, revenue generated by industrial (alluvial or kimberlite) production is given by:

$$y_{ki} = \rho_{ki}\,\bar{i}_{ki}, \quad y_{ai} = \rho_{ai}\,\bar{i}_{ai}$$

where ρ is a constant that defines the yield from industrial production. Revenue generated by artisanal alluvial diamond production is given by:

$$y_{aa} = \rho_{aa} N^P a_{aa}$$

where ρ_{aa} is a constant defining the yield from artisanal alluvial production, N^P denotes the number of peasants in a cell, and $a_{aa} = a - a_{ai}$, with $a_{ai} = \frac{\bar{i}_{ai}}{\mu_{ai,\max}}$. And lastly, revenue generated by agricultural production is given by:

$$y_{ag} = \left(1 + \phi \cdot \left(1 - \exp^{-\frac{\bar{i}_{ag}}{\varphi_{ag}}}\right)\right) \cdot \rho_{ag} N^p$$

and where ρ_{ag} is the productivity of the peasants, N^P denotes the number of peasants in a cell, ϕ is the maximum increase in productivity generated by investment, and φ_{ag} is a scaling factor that determines the requisite level of investment for a given level of revenue. Due to the highly organized and controlled process of diamond mining in

industrial production, we assume that the leader in control is the sole recipient of revenue from all industrial production ($s_{ki} = 1$ and $s_{ai} = 1$). Turning to artisanal extraction and agriculture, we specify s_{aa} and s_{ag} as increasing with investment in each sector, and assume that in the absence of investment, the minimum share of revenue going to $\dot{A}$, $\dot{B}$ is given by $s_{aa,\min}$, $s_{ag,\min}$, and the maximum share by $s_{aa,\max}$, $s_{ag,\max}$:

$$s(\bar{i}) = s_{\min} + (s_{\max} - s_{\min})(1 - e^{-\frac{\bar{i}}{k}}),$$

where k_{aa} and k_{ag} are scaling factors that determine the requisite level of investment for a given share. Note that while investment in the artisanal sector has no direct influence on total revenue, it does affect the ability of $\dot{A}$, $\dot{B}$ to tax peasant revenue.

A sectoral and spatial *spending strategy* determines the share of revenue $\dot{A}$, $\dot{B}$ allocates to (*i*) coercive power, (*ii*) robbery, (*iii*) economic investment, and (*iv*) social welfare payments to peasants, as well as the distribution of revenue across cells in the landscape.[1] A *control strategy* determines which cells on the landscape $\dot{A}$, $\dot{B}$ seek to control, as well as the distribution of coercive power over these cells, as a function of the cell's (*i*) resource base, (*ii*) peasant population, (*iii*) distance to capital, (*iv*) proximity of other cells under the agent's control. The combination of spending and control strategies yield a set of stylized "modes of play" for $\dot{A}$, $\dot{B}$:

- *Robbery* is a "predatory" strategy in which leaders maximize personal profit by appropriating tax revenue from the economy, while neglecting further investment and relinquishing control of unprofitable areas.
- *Social Welfare* is a "populist" strategy designed to increase peasant support through high levels of social spending.
- *Territorial Control* is a "militant" strategy in which spending on coercive power to increase and/or maintain physical control over territory is paramount.
- *Benevolent Rule* is an "ideal" strategy in which leaders balance investment in the economy with spending on coercive power and social welfare.

Sectoral Spending Decisions
The *spending strategy* determines the share of revenue allocated to: (*i*) the expansion of coercive power (i.e. military spending); (*ii*) personal consumption; (*iii*) investment in the industrial extraction of resources (kimberlite or alluvial)—a mode of production that is easier to tax; (*iv*) investment in artisanal alluvial extraction, harder to tax but preferred by $\dot{B}$; (*v*) investment in agricultural extraction, which may provide a lower rate of return compared to other economic sectors; and (*vi*) investment in welfare payments to peasants.

Spatial Spending Decisions
After allocating revenue across categories, a leader distributes these funds over grid cells by:

1. Assigning investment targets to every grid cell under his/her control:
   (a) In the kimberlite and alluvial industrial sectors, the target is the maximal investment allowed
   (b) In the alluvial artisanal sector, the target is proportional to the size of deposits available for artisanal mining
   (c) In the agricultural sector, the target is proportional to the number of peasants in the cell
   (d) With respect to social spending, the target is defined as the desired level of peasant sympathy (-10 for $\dot{B}$, +10 for $\dot{A}$)

[1] Peasant revenue from social welfare y_{sw}^{p} is a function of the importance of the cell, and difference between actual and maximal levels of peasant support.

2. Distributing available funds in proportion to the difference between the targeted and the current level of investment in a cell.

Peasant Support and Migration

Next, we define a measure of peasant *support* s^P for the "accountable agent" i.e. the leader $\dot{L}$ in control of a given cell (Note that support need not be limited to leaders of one's own group, and that accountability is limited to leaders alone). This measure ranges from -10 to +10 (where -10 denotes total support for $\dot{B}$, +10 denotes total support for $\dot{A}$, and 0 denotes neutrality) and depends upon: (*i*) current revenue; (*ii*) changes in revenue over time; (*iii*) the coercive power of the "accountable agent"; and (*iv*) the ethnicity of the "accountable agent". Specifically, we take the difference between actual revenue y^P and a reference revenue y^P_{ref} and the difference between y^P and the past revenue y^P_{past}. Let y^P_{past} be weighted sum of past revenue:

$$y^P_{past}(t+1) = k_{ws}\ y^P_{past}(t) + (1-k_{ws})\ y^P(t)$$

Where $k_{ws} \in [0,1]$ represents the "length" of memory. It follows that as k_{ws} decreases, the rate at which a peasant "forgets" the past increases. We then specify a function $h(c^a)$ which describes how peasant support is affected by the coercive power c^a of the leader in control of a cell, such that $h(c^a)$ begins at -1 for no coercive power, rises linearly to +1 for $c^a = c_{ideal}$, falls linearly to -1 for $c^a = c_{oppressive}$, and remains at -1 for $c^a \geq c_{oppressive}$. This function is then weighted by a parameter k_{CP}. Lastly, support is affected by ethnic salience, such that if $e_i > 0$ then k_e equals -1 if the peasants and leader are from different groups, 1 if the peasants and leader are from the same ethnic group, and 0 if $e_i < 0$. Adding these terms, and inserting them into a logistic function $\frac{1}{1+e^{-x}}$ yields:

$$\hat{s}^P(y^P, c^a, e_i) = \dot{L} \cdot 20 \cdot \left(\frac{1}{1 + e^{-\left(\frac{y^P - y^P_{ref}}{k_{ref}} + \frac{y^P - y^P_{past}}{k_{past}} + k_{CP} h(c^a) + k_e(e_i) \right)}} - 0.5 \right)$$

where $\dot{L}$ equals -1 for $\dot{B}$, +1 for $\dot{A}$, and 0 otherwise. The update rule for $s^P(t)$ is:

$$s^P(t+1) = s^P(t) + \lambda_s(\hat{s}^P - s^P(t))$$

where λ_s captures the "inertia" or the rate at which a peasant adapts her sympathy to changes in economic well being.

Finally, peasants may move or migrate to "ethnic enclaves" using the following rules:

- For peasant i, every x_i timesteps,
  - IF $\dot{A}$ controls the cell AND IF $s_i^P < 5$ THEN $max\left(\frac{n_A \cdot q_c^{\dot{A}}}{10}\right)$ over mobility radius *m*
  - IF $\dot{B}$ controls the cell AND IF $s_i^P > -5$ THEN $max\left(\frac{n_B \cdot q_c^{\dot{B}}}{10}\right)$ over mobility radius *m*

That is, if s_i^P falls below 5 (-5), then peasant *i* will move a maximum distance *m* to a cell with the greatest number of co-ethnics $n_A(n_B)$, and highest degree of control $q_c^{\dot{A}}(q_c^{\dot{B}})$ exercised by a leader from the peasant's ethnic group. The

migration of peasants has implications for control, given that high levels of peasant support lowers the cost of control, whereas this cost increases in the absence of strong support.

Conflict: Coercive Power, Control, and Civil War

Coercive power c is cell- and leader-specific, updated every timestep by new investment i_c, depreciation δ_c (to reflect the normal wear of equipment and attrition), and loss *l* incurred as a result of conflict, and change in the density of "ethnicized" φ_{e^P} peasants (the number of peasants for whom ethnic salience *e* equals 1):

$$c(t+1) = c(t) + i_c(t) - \delta_c(t) - \iota(t) + \varphi_{e^P}(t)$$

Control $q_c \in [-10, 10]$ is a function of the average peasant support in the cell ($\bar{s}^P$), the coercive power ($c^{\dot{A}}$ and $c^{\dot{B}}$) of leaders in the cell, and the cell's distance from the capital city, with -10 denoting complete control by $\dot{B}$ of a cell and +10 denoting complete control by $\dot{A}$ of a cell. The *control strategy* determines exactly which cells on the landscape $\dot{A}$, $\dot{B}$ seek to control, as well as the distribution of coercive power over these cells, as a function of several cell specific characteristics. The first pertains to the existence of (kimberlite or alluvial) diamonds in the territory—in other words the expected revenue from extraction and taxation. Then there are characteristics of the population: whether a cell is densely populated, together with its ethnic composition. The third determinant of the control strategy is the distance from the capital, which imposes difficulties on government control, but facilitates insurgency or opposition. Lastly, $\dot{A}$, $\dot{B}$ consider the proximity of a cell to cells already under their control. The strategy assigns a *priority value v* to every cell, based upon the following factors and associated weights given by γ:

- the existence of kimberlite/alluvial diamonds in the cell ($\gamma_{kim}, \gamma_{all}$)
- peasants population density (γ_{N^P})
- peasant ethnicity (γ_{e^P})
- distance from the capital ($\gamma_{cap,close}, \gamma_{cap,far}$)
- proximity of $\dot{A}$, $\dot{B}$ controlled cells ($\gamma^{\dot{A}}_{close}, \gamma^{\dot{B}}_{close}$)
- average control value in the cell and neighboring cells ($\gamma^{\dot{A}}_q, \gamma^{\dot{B}}_q$) is in favor of $\dot{A}$, $\dot{B}$

Based on these factors $\dot{A}$, $\dot{B}$ ignore cells whose priority value *v* is lower than a *priority threshold* τ and ignore all cells already under their own control. Specifically, $\dot{A}$, $\dot{B}$ choose *n* cells with the highest priority value, and build-up coercive power in these and neighboring cells. To determine *control*, we specify a control threshold $\tau_q > 0$, such that if $q_c > \tau_q$, the cell falls under the control of $\dot{A}$, if $q_c \leq -\tau_q$, the cell falls under the control of $\dot{B}$, and for $-\tau_q < q_c \leq \tau_q$, the cell is not controlled by either $\dot{A}$, or $\dot{B}$. Specifically, we use the log ratio of coercive power $\frac{c^{\dot{A}}}{c^{\dot{B}}}$ and modify this ratio by adding the term $v_c N^P$ (where N^P is the number of peasants in the cell and v_c is a constant):

$$\log\left(\frac{c^{\dot{A}} + v_c N^P}{c^{\dot{B}} + v_c N^P}\right)$$

As a result, the cost of shifting control increases with the size of the cell's peasant population. Next, we add $\bar{s}^P$ to account for the influence of aggregate peasant sympathy on the balance of power in a cell, and $\eta_c \frac{2(d_m - d)}{d_{\max}}$ to measure the effect of geography (where d is the distance from the cell to the capital city, d_m is the distance to the midpoint between the capital and the border, and $d_{\max}$ is the distance between a border cell and the capital), to obtain:

$$\log\left(\frac{c^{\dot{A}}+v_c N^P}{c^{\dot{B}}+v_c N^P}\right)+\varsigma_c \bar{s}^P+\eta_c \frac{2(d_m-d)}{d_{\max}}$$

where ς_c weights the influence of the peasant sympathy and η_c the influence of geography. The logistic transformation (since we define $q_c \in [-10,10]$) yields:

$$q_c = 20\cdot\left(\frac{1}{1+e^{-\left(\log\left(\frac{c^{\dot{A}}+v_c N^P}{c^{\dot{B}}+v_c N^P}\right)+\varsigma_c \bar{s}^P+\eta_c \frac{2(d_m-d)}{d_{\max}}\right)}}-0.5\right)$$

Note that conflict in a grid cell makes it impossible for either agent to control the cell.

Conflict occurs when $\dot{A}$, $\dot{B}$ seek to control the same cell, given that control is necessary for investment and profit. Specifically, conflict occurs when the coercive powers of both $\dot{A}$, $\dot{B}$ in a cell exceed a threshold τ_c , with loss l proportional to the magnitude and outcome of the conflict, such that:

$$l^{\dot{A}} = \alpha\ (1-f)\ c_{sum} \quad \text{and} \quad l^{\dot{B}} = \alpha\ f\ c_{sum}$$

where $f \in [0,1]$ is the conflict outcome variable ($f = 1$ being total victory by $\dot{A}$, and $f = 0$ total victory by $\dot{B}$), $c_{sum} = c^{\dot{A}} + c^{\dot{B}}$ is the sum of all coercive powers involved in the fight, and α is a parameter that determines the intensity of conflict (by scaling the losses). We define the conflict outcome variable f using the log-ratio of coercive power $\log\frac{c^{\dot{A}}}{c^{\dot{B}}}$, measuring control in cells surrounding the conflict $q_{sur} = \frac{1}{|M|}\sum_{i\in M} q_c^i$ (where M denotes the conflict cell and it's Moore Neighbors, q_c^i denotes control in cell *i*), using a distance function $\frac{2(d_m-d)}{d_{\max}}$, and introducing a stochastic term $X \sim N(0,\sigma^2)$ (where σ^2 is the amount of randomness we seek to introduce). Taking the sum of these terms in the logistic function $\frac{1}{1+e^{-x}}$ yields:

$$f\left(\frac{c^{\dot{A}}}{c^{\dot{B}}}, q_{sur}, X\right) = \frac{1}{1+e^{-\left(\log\frac{c^{\dot{A}}}{c^{\dot{B}}}+\lambda_c q_{sur}+\eta_c\frac{2(d_m-d)}{d_{\max}}+X\right)}}$$

where λ_c weights the influence of control in surrounding cells, and where η_c weights the influence of the geography. Control of the cell under contention shifts to the victorious agent, and in the case of widespread conflict, may result in a change of the EGIP.