**University of Wollongong**
**Department of Economics**
**Working Paper Series 2002**

http://www.uow.edu.au/commerce/econ/wplist.html

# Conflict, Political Structure and Economic Growth in Dual-Population Lands

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WP 02-19

# CONFLICT, POLITICAL STRUCTURE AND ECONOMIC GROWTH IN DUAL-POPULATION LANDS

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**Abstract:** The optimal consumption growth rate for a group in a strictly political federation in a dual-population land is lower than that under partition if the group is wealthier and has a lower population growth rate than its counterpart. Even in such circumstances the group may economically benefit from joining a federation that facilitates technological transfer as long as the group's initial technology is inferior to the hybrid. The group's optimal consumption growth rate during a civil war is larger than those under partition and a strictly political federation if its rival's warfare is mainly aimed at inflicting casualties.

**Key words**: Economic Growth, Dual Population, Conflict, Partition, Federalism, Civil Wars, Apartheid, Integration

**JEL Classification Numbers**: D90, D72, D74, J19, P16

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**CONFLICT, POLITICAL STRUCTURE AND ECONOMIC GROWTH**

**IN DUAL-POPULATION LANDS**

## I. Introduction

The population of many lands is divided by factors such as origin, culture, religion and race into two major groups: Hindus and Muslims in the Indian sub continent, Hutus and Tutsis in Rwanda, Greeks and Turks in Cyprus, Maronites and Muslims in Lebanon, Jews and Palestinians in Israel-Palestine, Catholics and Protestants in Northern Ireland, Muslims and Orthodox Serbs in Bosnia Herzegovina, Pushtuns and Tadzhiks in Afghanistan, Sinhalese and Tamils in Sri Lanka, Indians and Melanesians in Fiji, and Blacks and Whites in South Africa, to mention a few. Conflicts between the two groups inhabiting these lands seem to be imminent and constitute a major aspect of their coexistence.

The recent economic literature on conflicts deals with three major issues: the foundations of conflicts, external conflicts and internal conflicts. The literature on the foundations of conflicts views conflicts as emerging from a state of nature where property rights are not well defined. In the absence of complete assignment of enforceable property rights no agent can be prevented from coercing another agent, and seizing and defending resources. Hirschleifer (1995) calls this state anarchy and shows that its spontaneous order is fragile and is sustainable only when there are strongly diminishing returns to fighting effort and incomes exceed the viability minimum. Cooperation is a possible outcome even when property rights do not exist. Skaperdas (1992) shows that there is a possibility of cooperation when win probabilities are significantly different only for large arms differentials and when their marginal contributions to useful production are similar. Grossman and Kim (1995) analyze a general equilibrium model of resource allocation to appropriation and productive activities. They focus attention on a non-aggressive equilibrium in which no resources are allocated to offensive weapons, defined as predatory instruments, and claims to property are fully secure.

The literature on external conflicts stresses political and economic factors that may influence wars. For instance, Grafinkel (1994) studies the interactions between domestic politics and international conflicts and shows that political party competition associated with electoral uncertainty leads to a decline in military spending. She argues that democratic institutions can be thought of as a possible "pre-commitment" mechanism that reduces the severity of conflict between nations. Hess and Orphaniedes (2001), however, dispute the idea that democracy and democratic institutions reduce conflict and war frequency among nations. Bearce and Fisher (2002) argue that given geographical parameters, there is an inverse relationship between trade and war. (See also Dorussen, 2002.) Nafziger and Auvinen (2002) show how other economic factors such as income inequality and pervasive rent-seeking by a ruling elite are linked to war and state violence. Hess and Orphanides (1995) stress the role of recessions as triggering foreign conflict. Blomberg and Hess (2002) argue that a recession combined with external conflict increases the probability of internal conflict.

In the context of internal conflicts, which is the focus of our paper, the utmost interest is given by the literature to civil wars. Collier and Hoeffler (1998) argue that civil wars happen if rebels' perceptions of benefits outweigh the costs of rebellion. Civil wars are motivated either by "greed" for private gains or by "grievance" stemming from the degree of autocracy of the regime and ethnic and religious differences. (Cf., Collier and Hoeffler, 2000). Evidence provided by Collier and Hoeffler (2002) show that civil wars in Africa are mainly due to poor economic performance. In addition to political-economic factors, the roles of ideology, ethnicity and religion in civil wars are emphasized. Elbadawi and Sambanis (2002) find that democracy is negatively associated with civil violence and that civil-war prevalence is positively associated with ethnic fractionalization. Gershenson and Grossman (2000) argued that for civil conflict to be never ending the ratio values attached to political dominance can be neither too large nor too small. Reynal-Querol (2002) concludes that religious differences are a social cleavage more important than linguistic differences in the development of a civil war and that democracy significantly reduces the incidence of ethnic civil war. Agadjanian and Prata (2002) discuss the effects of civil wars on population. Murdoch and Sandler (2002) examine the effect of civil wars on growth and on human and physical capital.

Civil war is one possible outcome of internal conflicts in dual-population countries. Partition of the land between the rival groups and, alternatively, a formation of a federation are possible outcomes representing two polar approaches for settling conflicts peacefully. Each of these three possible outcomes of conflicts evolves from a combination of socioeconomic characteristics of the rival groups. Table 1 below focuses on a few, major, characteristics: human and material capital disparities, cultural and spiritual differences and degree of group cohesion. For exposition purpose, these characteristics are aggregated into two composite ones. The entries of the table indicate the likely political equilibrium in dual-population lands for various levels of differences between the two rival groups with regard to these composite characteristics. The rationale underlying these political equilibrium outcomes is based on the premises that:

i. when the cultural differences are large (small) and the degree of cohesion of each of the groups is high (low) the costs of tolerating a peaceful coexistence are high (low) for each group; and

ii. when the human and material capital disparities are large the costs of civil war for the richer (poorer) group are low (high), whereas when both groups are equally endowed with material wealth and population, the costs of civil war for each group are high.

Table 1. Possible equilibria for various combinations of socioeconomic differences between the two inhabiting groups

| | *1. Small cultural&spiritual differences and low group cohesion* | *2. Medium cultural&spiritual differences and medium group cohesion* | *3. Large cultural&spiritual differences and high group cohesion* |
|---|---|---|---|
| *1. Small human and material capital disparities* | **Integration** or **Federation** (stable) | **Federation** (unstable) or **Partition** | **Partition** |
| *2. Medium human and material capital disparities* | **Federation** (stable/unstable) | **Partition** or **Civil War** | **Partition** or **Civil War** |
| *3. Large human and material capital disparities* | **Federation** (unstable) | **Federation** (unstable) | **Civil War** |

The term civil war is used in Table 1 and the paper as a generic title representing any coercive interaction between the two groups, including a large scale war (a likely event in case 2-3 and to a lesser extent in case 2-2), guerrilla warfare, ethnic cleansing, and submission of one group to its rival (likely outcomes in case 3-3). Similarly, a federation can be stable or unstable. When the cultural and spiritual differences between the groups are small and the degree of cohesion of each group is low and the level of human and material disparity between the groups is low, the probability of a stable federation, or even integration, is high (case 1-1). When the groups are considerably cohesive and the cultural and spiritual differences between them are substantial, or when the human and material capital disparities between the groups are large, a federation is likely to be unstable (cases 1-2, 3-1 and 3-2). Partition is likely to be a stable equilibrium when the cultural and spiritual differences between the groups are large and each group is highly cohesive (cases 1-3 and 2-3).

There may also be *external* factors affecting the interaction between the two rival groups and, subsequently, their political equilibrium. Although our analysis is focused on internal factors, the effect of external factors is indirectly incorporated through the groups' perceptions and consideration of their differences. On the one hand, external factors such as close relationship with the motherlands might polarize a local population by strengthening ethnic identity.[1] On the other hand, external factors such as a threat of invading peoples may moderate groups' perception of the magnitude and importance of their socioeconomic differences and increase their degrees of mutual tolerance and

[1] As in the case of Greeks and Turks in contemporary Cyprus.

solidarity.[2] Facing a common enemy, rival groups may form a federation and encourage integration. Left alone, they might prefer partition, or fight one another.

The purpose of this paper is to extend the economic growth theory to the case of dual-population lands in the aforementioned political situations: partition, federation and civil war. The analysis concentrates on the role of two important demographic and economic factors such as population growth rate and wealth disparities and compare the optimal consumption growth rates across the possible political outcomes. This comparison identifies the conditions that may generate political instability and transition from one political state of affair to another under the assumption that the members of each group are lifetime-utility maximizers.

Our presentation of the possible political situations in dual-population lands and their implications for growth starts in section II with a partition scenario because the analysis of this case can serve as benchmark for the analytically more complicated cases of federation and civil war. Section III analyzes the federation outcome and its implication for growth and convergence when the federation is strictly political and, alternatively, when the federation provides economic benefits through technological exchange and also when the federation facilitates a flow of capital and labor between the two groups. Section IV analyzes the civil-war outcome and its implication for growth and convergence with a distinction between casualty-intensive (bloody) warfare and capital-destruction-intensive (sabotage) warfare. Section V concludes.

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[2] As in the cases of the Athenians and Spartans in ancient Greece, the tribes of Israel and, subsequently, the kingdoms of Judah and Israel in the biblical period.

## II. Partition

Our presentation of this case is based on the following assumptions.

*Assumption 1 (demographics):* The land is inhabited by two groups ($i = 1,2$). The groups are highly cohesive (i.e., the number of intermarriages is negligible) and the size of each group is given by an exponential growth function

$$P_i(t) = P_i^0 e^{n_i t} \qquad (1)$$

where $P_i^0$ and $n_i$ are the initial size and the population growth rate of the *i*-th group, respectively.

*Assumption 2 (intolerance and deterrence):* There are considerable cultural and spiritual differences between the groups, and at least one of the groups prefers a split to coexistence under a single political-economic system. None of the groups is relatively very poor in human and material capital and can be easily subjected by the other.

*Assumption 3 (utility):* The groups are homogenous with regard to preferences. The instantaneous utility from consumption ($c$) of a member of group $i$ is given by $u_i(c_i(t))$, with $u_i' > 0$ and $u_i'' < 0$. For tractability, the explicit form

$$u_i = c_i^{b_i}, \ 0 < b_i < 1, \qquad (2)$$

is considered. The member's lifetime utility is additively separable in the instantaneous utilities and displays a non-negative invariant rate of time preference $r_i$.

*Assumption 4 (production and income):* The groups are homogenous with regard to production. Under separation, the aggregate output of each group is given by a Cobb-Douglas production function homogenous of degree 1 in labor and capital and satisfying Inada's conditions. Consequently, the income of a member of each group is a concave function of the capital-labor ratio in the respective group, i.e., $f_i(k_i(t))$ with $f_i' > 0$ and $f_i'' < 0$.

*Assumption 5 (capital accumulation):* Capital is linearly depreciated, which, in conjunction with assumptions 1 and 4, implies that, under separation, the instantaneous change in the capital of member of each group $i = 1,2$ is given by

$$\dot{k}_i(t) = f_i(k_i(t)) - c_i(t) - (d_i + n_i)k_i(t) \qquad (3)$$

where $d_i$ is the capital depreciation rate in group $i$.

In view of assumptions 1 and 2, the costs of civil war are high, but also the costs of tolerating coexistence in a federation are high. Hence, the political Nash equilibrium is division of the land into two sovereign states or autonomous parts.[3] Under partition, each group's optimal (lifetime-utility maximizing) consumption change follows the well known, Ramsey-type, no-arbitrage rule:

$$\hat{c} \equiv \frac{\dot{c}_i(t)}{c_i(t)} = \frac{f_i'(k_i(t)) - (r_i + d_i + n_i)}{1 - b_i} \qquad (4)$$

which states that the instantaneous rate of change in the optimal consumption for each group is equal to the difference between the marginal product and user cost of capital, deflated by the degree of concavity (one minus the elasticity) of the instantaneous utility function of the members.

[3] Notable examples are the partitions of the Indian sub-continent in 1947/8, Palestine in 1947/8, and Cyprus in the early 1970s.

## III. Federation

Three types of federations are considered. The first is a strictly political federation. The second allows a limited economic cooperation - technological transfer between the two groups comprising the federation. The third also allows flow of capital and labor and intermarriages, which may transform the dual-population society into an integrated one.

*III.1 Federation without Economic Cooperation*

*Assumption 6 (strictly political federation):* The two groups are united into a political federation. However, each group retains its own identity and economic interests: there is no (significant) mobility of population and capital and there is no (significant) transfer of technology.

*Assumption 7* (*continuation and dissolution*)*:* There is no upper-bound on the federation life expectancy. However, the federation might be dissolved at every instance *t* with some probability $f(t)$, whose cumulative distribution function is $F(t)$. The probability of continuation (survival) of the federation beyond t (i.e., $\Phi(t) = 1 - F(t)$ ) diminishes with the wealth disparity between the two groups as displayed by

$$\Phi(t) = e^{-m[k_1(t) - k_2(t)]^2} \qquad (5)$$

where $m$ is a positive scalar indicating the sensitivity of the federation's existence to wealth disparity between the groups. The underlying rationale is that wealth differential intensifies relative deprivation, social tension and, subsequently, political instability – the larger the groups' wealth differential the greater the discontent of the poorer one with the federal system.

*Assumption 8 (federal social welfare):* The instantaneous federal social welfare (*FSW*) level is given by the sum of the instantaneous utilities of the individuals affiliated to the federation. Recalling assumptions 4 and 5 that the members of each group are identical,

$$FSW(t) = P_1(t)u_1(c_1(t)) + P_2(t)u_2(c_2(t)) . \tag{6}$$

*Assumption 9 (imaginary crossbreed):* The representative agent of the federation is an imaginary crossbreed of the two groups. His instantaneous well being, $u(t)$, reflects an equal share in the federation's instantaneous social welfare level and hence is found by dividing the instantaneous federal social welfare by the federation's population

$$u(t) = \frac{FSW(t)}{P_1(t) + P_2(t)} . \tag{7}$$

By substituting Eq. (6) into Eq. (7), the instantaneous well being of the federal representative, imaginary crossbreed is equal to the weighted average of the groups' representatives' instantaneous utilities

$$u(t) = \left( \frac{P_1(t)}{P_1(t) + P_2(t)} \right) u_1(c_1(t)) + \left( \frac{P_2(t)}{P_1(t) + P_2(t)} \right) u_2(c_2(t)) . \tag{8}$$

*Assumption 10 (expected lifetime utility):* The federal representative imaginary crossbreed is aware of the fragility of the federation and the possibility of its dissolution. He has constant, non-negative, rate of time preference ( $r \geq 0$ ). He chooses the consumption trajectories of his composite personality so as to maximize his expected-lifetime utility

$$J = \int_0^{\infty} f(t) \int_0^{t} e^{-rt} u(t) dt dt \ . \qquad (9)$$

To solve the federal representative imaginary crossbreed's problem note that, as explained in Appendix A, $J = \int_0^{\infty} f(t) \int_0^{t} e^{-rt} u(t) dt dt = \int_0^{\infty} e^{-rt} u(t) \Phi(t) dt$ , recall assumption 5 and express the consumption of each group as

$$c_i(t) = f_i(k_i(t)) - (d_i + n_i) k_i(t) - \dot{k}_i(t) \ . \qquad (10)$$

By substituting this expression (Eq. (10)) into the imaginary crossbreed's instantaneous utility function and applying Euler equation, the optimal consumption growth rate of each group $i$ affiliated to the federation is given, as explained in a greater detail in Appendix B, by the following no-arbitrage rule

$$\hat{c}_F \equiv \frac{\dot{c}_i(t)}{c_i(t)} = \frac{f_i'(k_i(t)) - (r + d_i + n_i)}{1 - b_i} - \frac{(n_j - n_i) p_j(t)}{1 - b_i} - \frac{\frac{2m}{b_i}[k_i(t) - k_j(t)] c_i(t)}{1 - b_i} \qquad (11)$$

where $j$ denotes the counterpart group whose population share in the federation is

$$p_j(t) = P_j(t) / [P_1(t) + P_2(t)] \ . \qquad (12)$$

For each of the groups, the first term on the right-hand side of this strictly political federation's no-arbitrage rule is identical to the no-arbitrage rule in partition, but with the groups' average rate of time preference replacing that of the individual group.

The second term on the right-hand side of Eq. (11) indicates that the effect of the *j*-th group's share in the federation's population on the optimal rate of change of consumption of the *i*-th group is negative (positive), and hence providing an incentive for the *i*-th group to withdraw from (remain in) the federation, if the *j*-th group's rate of population growth is larger (smaller) than that of the *i*-th group. When the populations of both groups grow at the same rate, the effect of the *j*-th population share on the i-th group's consumption growth rate is nil.

The third term on the right-hand side of Eq. (11) reveals that the wealth disparity between the members of group *i* and the members of group *j* adversely affects the federation's stability and prospect of survival and moderates the optimal consumption growth rate of the *i*-th group members.

Thus, starting from the same initial capital-labor ratio and with a rate of time preference not considerably larger than that of the imaginary crossbreed, the optimal rate of change in the consumption of group *i* members in a strictly political federation ($\hat{c}_F$) is lower than their optimal consumption growth rate under sole sovereignty ($\hat{c}$) in the case of partition if their population growth rate is lower than that of their *j*-th group counterparts and if they are wealthier than their *j*-th group counterparts. In sum, group *i* prefers to secede from a political federation characterized by no economic cooperation if its rate of time preference is not considerably larger than that of the imaginary crossbreed so that:

$$\{(n_j > n_i) \text{ and } (k_i(t) > k_j(t)\} \Rightarrow \{\hat{c}_F < \hat{c}\}. \qquad (13)$$

*III.2 Federation with Partial Economic Cooperation*

Let us now relax a part of assumption 6 and allow exchange of technology between the two groups comprising the federation. Movement of labor and capital remains prohibited.

*Assumption 11 (cost-free and perfect technological transfer):* Capital does not become obsolete by technological transfer and adjustment costs are negligible. The two groups perfectly and immediately exchange technological knowledge.

This assumption and (the earlier assumed) rational behavior imply that the two groups use the same hybrid technology, $f$, since $f(k_i(t)) \geq f_i(k_i(t))$ for each group $i = 1,2$ at every instance.

In this case of partial economic cooperation, the optimal consumption growth rate of each group $i$ affiliated to the federation is given by the following no-arbitrage rule

$$\hat{c}_C \equiv \frac{\dot{c}_i(t)}{c_i(t)} = \frac{f'(k_i(t)) - (r + d_i + n_i)}{1 - b_i} - \frac{(n_j - n_i)p_j(t)}{1 - b_i} - \frac{\frac{2m}{b_i}[k_i(t) - k_j(t)]c_i(t)}{1 - b_i}. \quad (14)$$

In contrast to the strictly political federation case, the members of group $i$ may economically benefit from joining the federation, even when they are wealthier and multiply in a lower rate than their counterparts, if they significantly gain from technological transfer; namely, if

$$f'(k_i(t)) - f_i'(k_i(t)) + (r_i - r) > (n_j - n_i)p_j(t) + \frac{2m}{b_i}[k_i(t) - k_j(t)]c_i(t)$$

then $\hat{c}_c > \hat{c} > \hat{c}_F$ for any $k_i$ and $t$.

*III.3 Federation with Broad Economic Cooperation and Integration*

The case of a broader economic cooperation and integration requires a further relaxation of assumption 6 to allow capital and labor flows and a relaxation of assumption 1 to allow intermarriages. Significant, continuous flow of capital and labor and intermarriages can be interpreted as a process of *integration* of the two groups. As indicated by Table 1, integration may take place when the cultural, spiritual and human and material wealth differences between the groups are small and when each group is not highly cohesive (in which case, $m \to 0$). When integration starts the crossbreed is no longer imaginary. When integration is completed, the crossbreed is dominant. The optimal consumption growth rate of the society of crossbreeds is given by the Ramsey-type no arbitrage rule -- the first term on the right-hand side of Eq. (14) but with time-preference rate, population-growth rate, depreciation rate and technology characterizing the society of crossbreeds.

## IV. Civil-War

In civil war, each group makes offenses against the other. Group *i* takes into account that its own effort in carrying hostile activities ($h_i$) increases its satisfaction, but adversely affects its capital accumulation due to divergence of resources from production to warfare activity. In the same vein, the effort of the antagonist group ($h_j$) inflicts casualties on group *i* (i.e., reduces the population growth of group *i*), and damages its current capital stock (i.e., accelerates the depreciation rate of the capital stock of group *i*). These aspects of civil-war are more formally presented by the following assumptions.

*Assumption 12 (war-time utility):* In addition to, and separately from, satisfaction from consumption, each group generates instantaneous utility from carrying hostile activities against its adversary. That is,

$$u_i(t) = u_i(c_i(t), h_i(t)) \tag{15}$$

where $\frac{\partial u_i}{\partial c_i} > 0$, $\frac{\partial^2 u_i}{\partial c_i^2} < 0$, $\frac{\partial u_i}{\partial h_i} > 0$, $\frac{\partial^2 u_i}{\partial h_i^2} < 0$, $\frac{\partial^2 u_i}{\partial h_i \partial c_i} = 0 = \frac{\partial^2 u_i}{\partial c_i h c_i}$.

*Assumption 13 (war-time capital accumulation):* The war effort reduces the $i$-th group's capital-investment possibilities. In addition, the hostile actions carried by its adversary adversely affect the $i$-th group's population growth and capital stock. More specifically,

$$\dot{k}_i(t) = f_i(k_i(t)) - c_i(t) - h_i(t) - [\delta_i(h_j(t)) + \nu_i(h_j(t))]k_i(t) \tag{16}$$

where, $\frac{\partial \delta_i}{\partial h_j} > 0$, $\frac{\partial^2 \delta_i}{\partial h_j^2} < 0$, $\frac{\partial \nu_i}{\partial h_j} < 0$, $\frac{\partial^2 \nu_i}{\partial h_j^2} < 0$.

In this differential game we assume open-loop strategies. The Hamiltonian corresponding to each group $i$ problem of choosing its consumption and hostility trajectories can be expressed as:

$$\begin{aligned} H_i(t) = e^{-\rho_i t} u_i(c_i(t), h_i(t)) &+ \lambda_i(t)\{f_i(k_i(t)) - c_i(t) - h_i(t) - [\delta_i(h_j(t)) + \nu_i(h_j(t))]k_i(t)\} \\ &+ \lambda_j(t)\{f_j(k_j(t)) - c_j(t) - h_j(t) - [\delta_j(h_i(t)) + \nu_j(h_i(t))]k_j(t)\} \end{aligned} \tag{17}$$

and the first-order conditions are

$$\dot{l}_i(t) = -l_i(t)\{f_i'(k_i(t)) - [d_i(h_j(t)) + n_i(h_j(t))]\} \tag{18}$$

$$e^{-r_i t} u_i'(c_i(t)) - l_i(t) = 0 \tag{19}$$

$$e^{-r_i t} u_i'(h_i(t)) - l_i(t) - l_j(t)\left[\frac{\P d_j}{\P h_i} + \frac{\P n_j}{\P h_i}\right] k_j(t) = 0\,. \tag{20}$$

Consistently with assumption 12, let

$$u_i = c_i^{b_i} + h_i^{g_i} \tag{21}$$

then the optimal consumption growth rate of each group $i$ in civil war is given by

$$\hat{c}_W \equiv \frac{\dot{c}_i(t)}{c_i(t)} = \frac{f_i'(k_i(t)) - (r_i + d_i(h_j) + n_i(h_j))}{1 - b_i}\,. \tag{22}$$

Comparing the *civil-war no-arbitrage rule* of consumption to the *partition no-arbitrage rule* of consumption, it is interesting to note that when the hostile actions taken by group *j* are mainly and effectively directed to inflict casualties upon group *i* than to damage its capital stock, the *civil-war* rate of growth of the *i*-th group's consumption is larger than the *partition* rate of growth of its consumption and, consequently, also exceeds its rate of consumption growth in a strictly political federation. That is, $\hat{c}_W > \hat{c} > \hat{c}_F$ for the group (*i*) on the receiving hand. The underlying rationale is as follows.

Recalling assumption 13, when the actions of group *j* are mainly directed to inflict casualties and are effective, the capital-labor ratio's depreciation rate for group *i* during the civil-war $(d_i(h_j) + n_i(h_j))$ and, consequently, its user-cost of (per capita) capital are smaller than those under partition. Moreover, starting from the same initial capital-labor ratio and consumption level, per-capita capital accumulation in civil war by group *i* is smaller than that under partition due to diversion of resources to military activities and destruction inflicted by group *j*'s operations. Recalling that the production function is concave, group *i*'s marginal product of capital in the civil war is larger than that under partition. In sum, group *i*'s marginal-product and user-cost differential in a casualty-intensive warfare launched by group *j* is larger than that under partition and, in view of equations (4) and (22), facilitating a higher consumption growth rate for group *i*.[4]

The above argument suggests that, when both groups are sufficiently large, each group "prefers" (from the perspective of consumption-maximizing-lifetime utility) a *casualty-intensive (bloody) warfare* by its adversary to a *capital-damaging (sabotage) warfare*. In contrast, in a sabotage-intensive warfare both the user costs and marginal product of per capita capital for the recipient group are larger than those under partition and strictly political federation. If the excess user cost (*vis-a-vis* partition and federation) is larger (smaller) than the excess marginal product of per-capita capital, the rate of growth of the recipient group's consumption during a sabotage-intensive campaign of its adversary is smaller (larger) than those under partition and federation. From the perspective of lifetime-utility-maximizing consumption, sabotage is, therefore, a more effectively harming course of action (in particular, for the smaller and poorer group) than bloody warfare.

Attention should also be paid to the evolution of the *level* of hostility. In this open-loop differential game the growth rate of hostility displayed by group *i* is:

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[4] This analytically derived result is consistent with the folk saying: "*Let us eat and drink; for to morrow we shall die*". (Bible, Isaiah 22:13)

$$\frac{\dot{h}_i(t)}{h_i(t)} = \left[g_i(g_i - 1) - (d_j''(h_i) + n_j''(h_i))\, l_j k_j\right]^{-1} \left[(b_i - 1) b_i c_i^{b_i - 2} \dot{c}_i + \left(d_j'(h_i) + n_j'(h_i)\right) [\, \dot{l}_j k_j + l_j \dot{k}_j \,]\right] \quad .(23)$$

(See Appendix C.)

As the sum in the brackets in the first term on the right-hand side of this expression is negative, group *i*'s rate of growth of hostility towards group *j* increases with the evolution of group's *j* wealth. That is, group *i* becomes more aggressive as group *j*'s capital stock grows along time.

## V. Conclusion

When the costs of civil war are affected by human and material wealth disparities between the two groups inhabiting the land and when the costs of tolerating coexistence rise with the groups' cultural and spiritual differences and degree of cohesion, the equilibrium political state of affair is either partition, federation, or civil war, pending the particular combination of the groups' socioeconomic characteristics. The optimal consumption trajectories associated with these possible equilibrium political systems were compared. If the members of each group are lifetime-utility maximizers, this comparison identifies the conditions that may generate political instability and transition from one political state of affair to another.

Starting from the same initial capital-labor ratio, the optimal consumption growth rate for group *i* in a strictly political federation is lower than its optimal consumption growth rate under sole sovereignty in the case of partition if its population growth rate is lower than that of group *j* and if it is wealthier than group *j*. In contrast, the members of group $i$ may economically benefit from joining a federation, even when they are wealthier and multiply in a lower rate than their counterparts in group $j$, if the federation facilitates technological transfer and if their initial technology is inferior to the hybrid.

Our analysis suggests that the growth rate of a group's consumption during a civil war is larger than those attainable under partition and a strictly political federation if its adversary's warfare is mainly aimed at inflicting casualties. In a civil war, each group may prefer (from the perspective of consumption-maximizing-lifetime utility) a casualty-intensive warfare by its adversary to sabotage. The rate of growth of the recipient group's consumption during a sabotage-intensive campaign of its adversary is smaller (larger) than those under partition and federation if the extra user cost is larger (smaller) than the extra marginal product of per capita capital. From the perspective of consumption-maximizing-lifetime utility, sabotage is a more effective strategy than casualty-inflicting operations.

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## APPENDICES

### Appendix A: The Crossbreed's lifetime expected utility

*Claim:* $J = \int_0^{\infty} f(t) \int_0^{t} e^{-rt} u(t) dt dt = \int_0^{\infty} e^{-rt} u(t) \Phi(t) dt$ .

*Proof:* Let $F(t)$ is the cumulative density function associated with the probability of dissolution at $t$ (i.e., the probability of continuation up to $t$ ), then

$$f(t) = F'(t) \tag{A1}$$

and Eq. (9) can be rendered as

$$J = \int_0^{\infty} F'(t) \left\{ \int_0^{t} e^{-rt} u(t) dt \right\} dt = \int_0^{\infty} v(t) dU \tag{A2}$$

where,

$$v = \int_0^{t} e^{-rt} u(t) dt \tag{A3}$$

and

$$U = -(1 - F(t)) . \tag{A4}$$

The integration by parts rule suggests that

$$J = \int_0^{\infty} v dU = Uv - \int_0^{\infty} U dv . \tag{A5}$$

Note, however, that

$$Uv = -\left[ (1 - F(t)) \int_0^{t} e^{-rt} u(t) dt \right]_0^{\infty} = 0 \tag{A6}$$

because when evaluated at the lower limit

$$Uv = -\left[ (1 - F(0)) \int_0^0 e^{-rt} u(t) dt \right] = 0 \qquad \text{(A7)}$$

and when evaluated at the upper limit

$$Uv = -\left[ (1 - F(T)) \int_0^\infty e^{-rt} u(t) dt \right] = 0 \qquad \text{(A8)}$$

as

$$\lim_{t \to \infty} F = 1 . \qquad \text{(A9)}$$

Hence,

$$J = -\int_0^\infty U dv . \qquad \text{(A10)}$$

By virtue of equation (A3)

$$dv = e^{-rt} dt \qquad \text{(A11)}$$

and the substitution of equations (A4) and (A11) into (A10) implies

$$J = \int_0^\infty e^{-rt} u(t) \Phi(t) dt \qquad \text{(A12)}$$

where

$$\Phi(t) \equiv -u(t) = 1 - F(t) \qquad \text{(A.13)}$$

and indicating the probability of the survival of the federation at least until $t$ . *QED*

## Appendix B: The Crossbreed's optimal consumption growth rate

Following Appendix A and substituting Eq. (10) for $c_i$, the imaginary crossbreed's lifetime utility is

$$J = \int_0^{\infty} e^{-rt} \left\{ \sum_{i=1}^{2} p_i(t) u_i(\underbrace{f_i(k_i(t)) - (d_i + n_i) k_i(t) - \dot{k}_i(t)}_{c_i(t)}) \right\} \Phi(k_1(t), k_2(t)) dt . \qquad \text{(B1)}$$

By virtue of Euler equation, $\frac{\partial J}{\partial k_i} - \frac{d}{dt}\left( \frac{\partial J}{\partial \dot{k}_i} \right) = 0$, the necessary condition for maximum lifetime utility is

$$e^{-rt} p_i u_i'(c_i)[f_i'(k_i) - (d_i + n_i)]\Phi + e^{-rt} p_i u_i(c_i)\Phi_{k_i} + \frac{d}{dt}\left( e^{-rt} p_i u_i'(c_i)\Phi \right) = 0 \quad \text{(B2)}$$

which implies

$$p_i u_i'(c_i)[f_i'(k_i) - (r + d_i + n_i)]\Phi + p_i u_i(c_i)\Phi_{k_i} + \dot{p}_i u_i'(c_i)\Phi + p_i u_i''(c_i)\Phi \dot{c}_i + p_i u_i'(c_i)\dot{\Phi} = 0$$
.(B3)

Divide both sides of Eq. (B3) by $p_i u_i' \Phi$ and solve for $\dot{c}_i$ to obtain

$$\dot{c}_i = \frac{[f_i'(k_i) - (r + d_i + n_i)] + \left( \frac{u_i}{u_i'} \right)\left( \frac{\Phi_{k_i}}{\Phi} \right) + \left( \frac{\dot{p}_i}{p_i} \right)}{-u_i''(c_i) / u_i'(c_i)} . \qquad \text{(B4)}$$

Note that by virtue of Eq. (2)

$$\frac{u_i}{u_i'} = c_i / b_i \qquad \text{(B5)}$$

and

$$-\frac{u_i''}{u_i'} = (1-b_i)/b_i c_i \,. \qquad \text{(B6)}$$

Note further that by virtue of Eq. (5)

$$\frac{\Phi_{k_i}}{\Phi} = -2m(k_i - k_j)\,. \qquad \text{(B7)}$$

By definition

$$\frac{\dot{p}_i}{p_i} \equiv \frac{\frac{d}{dt}\left(\frac{P_i}{P_i + P_j}\right)}{\frac{P_i}{P_i + P_j}} \qquad \text{(B8)}$$

and recall Eq. (1)

$$\frac{\dot{p}_i}{p_i} = (n_i - n_j)p_j\,. \qquad \text{(B9)}$$

Eq. (11) is obtained by substituting Eq. (B5) - Eq. (B9) into Eq. (B4) and dividing both sides by $c_i$.

## Appendix C: The optimal rate of change of hostility

By differentiating

$$e^{-r_i t}u_i'(h_i(t)) - l_i(t) - l_j(t)\left[\frac{\partial d_j}{\partial h_i} + \frac{\partial n_j}{\partial h_i}\right]k_j(t) = 0 \qquad \text{(C1)}$$

with respect to time:

$$e^{-r_i t}\left[u_i''(h_i(t))\ \dot{h}_i(t)\ -\ r_i u_i'(h_i(t))\right] - \dot{l}_i(t) - \dot{l}_j(t)\left[\frac{\partial d_j}{\partial h_i} + \frac{\partial n_j}{\partial h_i}\right]k_j(t)$$

$$-\ \dot{k}_j(t)\left[\frac{\partial d_j}{\partial h_i} + \frac{\partial n_j}{\partial h_i}\right]l_j(t)\ -\ l_j(t)\left[\frac{\partial^2 d_j}{\partial h_i^2} + \frac{\partial^2 n_j}{\partial h_i^2}\right]k_j(t)\ \dot{h}_i(t)\ = 0$$

(C2)

and by rearranging terms, equation (23) is obtained.