Why Are Ethnically Divided Countries Poor?

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Abstract

This paper presents a dynamic game with capital accumulation of war between ethnic groups. Ethnically divided countries are more prone to fighting wars and the threat of war reduces income. Ethnic divisions lead to pressure for the government to redistribute resources from some ethnic groups to other groups. Groups fight each other to control redistribution policy. The model can account for 70 percent of the gap in income levels between countries with and without ethnic divisions. Redistribution distorts investment decisions and war diverts and destroys resources. Lower levels of development occur even in cases where no war is observed. The incidence of civil war increases with ethnic heterogeneity. In ethnically homogeneous countries, majority groups can easily raise armies to deter minorities from fighting. Aid is less effective in ethnically divided countries and can cause civil wars. Up to 15 percent is lost to increased fighting.

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1 Introduction

Ethnically divided countries tend to be poorer than homogeneous countries. This paper presents a model that can account for most of the gap in income between ethnically homogeneous and ethnically divided countries. In addition, the model can explain the relationship between ethnic divisions and civil war and shows that foreign aid is less effective in ethnically divided countries

Ethnic divisions are associated with poor economic performance. Easterly and Levine (1997) find that ethnic divisions are associated with lower levels of income and slower economic growth. They claim that a third of the difference in economic growth rates between East Asia and Sub-Saharan Africa in the post World War Two era is due to the higher ethnic heterogeneity in Africa. Over the same period, ethnic divisions have also been associated with civil war. Elbawadi and Sambanis (2002) find a robust correlation between ethnic divisions and the prevalence of civil war.

Why do ethnic divisions reduce income levels? I argue that ethnically divided countries are more prone to fighting wars and the threat of war reduces income. Ethnic divisions lead to pressure for the government to redistribute resources between ethnic groups. Ethnic groups may fight to control the government and its redistribution policy. Ethnically divided countries are more likely to allocate resources to fighting than to investment. To have a good chance of winning a war, a group must raise an army that is larger than its rival. The per capita cost of raising an army is lower for large groups relative to small ones. Therefore, when the ruling group is large relative to other groups, it is easy for the majority to raise an army to deter the other groups. Conversely, when groups are more evenly matched, it is difficult for the ruling group to deter the others. Therefore, the risk of war is higher in ethnically divided countries. Ethnic divisions cause more resources to be diverted from investment to the military.

In this paper, I present a model that combines a dynamic growth model with an economic model of civil wars. Households are divided into ethnic groups. An ethnic group is a collection of households who are altruistic toward each other and can coordinate their actions. Output is produced using capital and labor as inputs. Ethnic groups divide output between military spending, capital accumulation and consumption. A government taxes output and distributes it among the groups. Ethnic groups play a dynamic game to determine control of the government. It is initially controlled by one of the groups and coordinates its actions with that group. Other groups can use their armies to fight for control of the government. If groups choose to fight, control of the government is determined randomly. The group that spends the most on the military has the best chance of winning. Warring groups suffer damage to their output.

The main result of the paper is that the model can account for most of the gap in income levels between countries with and without ethnic divisions. Ethnically divided countries have lower levels of GDP per capita. The model can account for 70 percent of the difference between ethnically homogeneous and heterogeneous countries. In the model, ethnically divided countries have incomes that are 50 percent lower than ethnically homogeneous countries whereas in the data they are about 70 percent poorer.

Ethnically divided countries are poorer due to three effects. First, ethnically divided countries are more prone to fight wars. It is obvious that the damage war causes is detrimental to an economy. Second, since ethnically divided countries tend to fight more wars, they divert more resources into armies and away from productive uses. Third, the tendency to redistribute is stronger in ethnically divided countries, distorting investment decisions. In ethnically homogeneous countries, the majority is likely to be in power in the future. Therefore, the members of the majority can invest knowing the proceeds are unlikely to be expropriated in the future. In ethnically divided countries, the group in power has a high probability of being removed from power in the future. Thus, there is a good chance that proceeds of investment will expropriated, deterring households from investing.

While ethnically divided countries are more prone to war, the costs of war account for a small proportion of the gap between countries with and without ethnic divisions. Ethnically divided countries can have incomes more than a third lower than homogeneous countries even if they do not fight wars. For countries that do fight wars, war damage and military spending represent no more than a quarter of the gap.

Even if no wars are fought, ethnically divided countries face investment distortions and divert resources to the military. Majorities in ethnically divided countries must divert more resources to the military to deter other groups from attempting to take power. The relative ease with which a large minority can raise an army requires majorities in ethnically divided countries to divert more resources to deterrence. Also, investment distortions are stronger in ethnically divided countries. Members of the majority know they are likely to remain in power and their investment decisions are not distorted. However, members of the minority know that proceeds of their investment will be expropriated, so their investment decisions are distorted. In more ethnically homogeneous countries, the minority is smaller and investment decisions are less distorted.

The model can also account for the relationship between ethnic divisions and civil war. Ethnically divided countries are more likely to fight a civil war, a relationship that matches the data. The intuition is the following: Ethnic groups wish to control the government to gain control of its revenue. Groups that are not in power can raise an army to attempt to seize power. To retain power, the ruling group must raise an army of its own to deter other groups from attempting a revolution. In countries with a large majority (ethnically homogenous countries), the per capita cost of raising an army is small for the majority. At the same time, it is costly for minorities to raise an army. Therefore, it is relatively easy for the majority to deter minorities from fighting. In more ethnically heterogeneous countries, groups are more evenly matched. Deterrence is more difficult since it is more costly for the majority and less costly for potential rivals to raise armies.

Ethnic divisions reduce the effectiveness of foreign aid. Aid increases the resources available to the government for redistribution, making control of the government more valuable. Therefore, groups are more willing to fight to control it. The increase in resources that aid brings may be dissipated by an increase in rent seeking. Up to 15 percent of the aid may be lost to increased rent seeking. Aid may also induce civil wars in countries that would not otherwise fight.

Poverty does not cause conflict. An ethnically divided country has the same incentives to fight whether or not it is poor. Consider an ethnically divided country that is prone to war. Increasing the wealth of all households, either by increasing the capital stock or improving productivity, will not make the country less prone to fighting wars. While the costs of diverting labor to raising armies is higher since labor is more productive, so is the benefit of controlling the government since there is more to expropriate. These two effects cancel each other out leaving the probability of war unchanged.

This paper contributes to a number of literatures. It advances the the development literature by providing a theory why ethnic divisions are detrimental to economic development. Another paper that takes up this issue is Benhabib and Rustichini (1996). Benhabib and Rustichini (1996) present a growth model with two groups where the government may favor one group over the other. They show that growth is slower when groups are treated unequally. This paper differs in that factions can influence the government's preferences by attempting to seize control of it. It also links the distribution of ethnic groups to lower development.

There is a theoretical literature analyzing conflict. Important work includes the analysis of contests in Hirshleifer (1991) and the model of insurrections in Grossman (1991). An introduction to the state of the literature can be found in Sandler (2000). The only theoretical papers in this literature that deals directly with ethnic conflict that I am aware of are Caselli and Coleman (2002) and Tangeras and Lagerlof (2002). Caselli and Coleman (2002) argue that ethnic groups are coalitions created to fight for resources. The focus of their work is the formation of ethnic groups. This paper seeks to link the distribution of ethnic groups to the level of conflict. Tangeras and Lagerlof (2002) analyzes the pattern of ethnic conflict in a dynamic model. The model of conflict is similar in spirit to this paper, but does not analyze the effect of conflict on output. Esteban and Ray (1996) present a model that links conflict and the distribution of groups. They define conflict by the amount of resources expended on influencing the policy outcome. In general, there is always conflict. This paper is concerned whether wars are fought or not.

The organization of the rest of the paper is as follows: Section Two discusses the measurement of ethnic divisions and the facts this paper seeks to explain. Section Three presents the model. Section Four discusses the equilibrium. Section Five presents the analytical results of the model and Section Six presents the results of numerical simulations. Section Seven concludes.

2 Ethnic Divisions: Data and Theory

This section describes the measurement of ethnic divisions and examines the relationship between ethnic heterogeneity, civil war and output. It discusses the theoretical basis of ethnicity used in the paper and applies this theory to data.

2.1 Data

The most common data set used to measure ethnic groups is found in the *Atlas Narodov Mira* (1964). For every country in the world in 1960, the Atlas splits the population into various ethnic groups and reports the population of each group. However, it does not describe how ethnic groups are defined. Inspection of the data indicates that divisions are cut primarily along linguistic lines. Racial and religious factors also appear to be important.

Once the population of a country is divided into ethnic groups, this information must be summarized into a statistic. I concentrate on the most common variable used in the literature: Ethnolinguistic Fractionalization (ELF). The measure ELF (using the Atlas's data) is the most widely used measure of ethnic divisions in the literature. It is calculated as follows. A country's total population N is divided into I groups, with each group's population denoted by N_i. ELF is given by

$$ELF = 1 - \sum_{j=1}^{I} (\frac{N_i}{N})^2.$$

This variable increases as (1) more groups are added (I increases) and (2) when the populations of groups become more equal.

While ELF is a very popular measure of ethnic divisions in the literature, it does not completely match the mechanism in model. Peace in the model is due to the ability of large groups to overwhelm small groups. Therefore, a better measure of ethnic divisions is the difference in population sizes between the largest and the next largest group. This measure, $DIFF$, is calculated as follows: Let N_1, N_2 be the populations of the first and second largest groups respectively and let N be the total population. $DIFF$ is given by:

$$DIFF = 1 - \frac{N_1 - N_2}{N}.$$

I calculated $DIFF$ using the *Atlas Narodov Mira* (1964) data[1]. The correlation between ELF and $DIFF$ is high, 0.96. As might be expected with such a high correlation, the relationship between $DIFF$ and conflict and development are very similar to that of ELF. In the empirical discussion that follows, I will report results for both ELF and $DIFF$.

2.2 Facts about Ethnic Divisions

This section explores in more detail the empirical relationship between ethnic divisions and other variables.

2.2.1 Ethnic Divisions and Redistribution

Ethnic divisions lead to redistribution. One method of redistribution is direct transfers. Barkan and Chege (1989) examine public spending in Kenya in the 1980s. Kenya is ethnically divided and the population is relatively segregated by district. There is some data on public spending by district. They compare the public expenditures by region after Daniel arap Moi, a Kalenjin, replaced Jomo Kenyatta, a Kikuyu, as President of Kenya in 1978. In the 1979/80 budget, 44 percent of road construction went to districts the authors identify as part Kenyatta's ethnic base compared to 32 percent for Moi's base. By the late 1980s, the percentages had shifted to around 20 percent and 65 percent respectively. (The populations of the two areas were equal.)

Redistribution also takes the form of patronage[2]. Alesina, et al. (1998) find that racially heterogeneous localities in the United States have larger public employment than homogenous ones. They suggest that this is a transfer to ethnically defined interest groups. Annett (2001) finds that government consumption is higher in ethnically

[1] I thank Igor Livshits for his Russian language translation.

[2] Robinson and Verdier (2002) provide a theory why patronage employment is used instead of direct transfers.

heterogeneous countries. Kuijs (2000) finds that public spending is less efficient in heterogeneous countries. This may be because public spending in diverse countries is more redistributive. Eisinger (1980) finds that cities that elect African-American mayors expand public employment of minorities faster than other cities. The portion of public contracts that went to minority owned firms also expanded rapidly. Erie (1988) shows that Irish control of city governments in the late nineteenth century led to large increases in Irish public employment.

2.2.2 Ethnic Divisions and Civil War

The incidence of civil war is associated with ethnic heterogeneity. Figure One shows the average years spent fighting a civil war in the period 1960 to 1994 compared to *ELF* in 1960[3]. *(Insert Figure One Here)* There is a strong positive relationship, which is confirmed in the first two regressions reported in Table 1. Both measures of ethnic divisions are strongly associated with civil war.

Table 1: Ethnic Divisions Regressions

Dep. Variable	CWYRS	CWYRS	LGDPW90	LGDPW90	LGDPW90	LGDPW90
Variable	Coeff. (t-Stat.)					
Constant	1.123 (1.10)	5.301 (5.55)	9.742 (58.80)	9.965 (58.48)	8.136 (42.93)	8.312 (41.84)
ELF	5.880 (2.96)		-2.016 (-6.084)	-1.923 (-5.930)		
DIFF		3.723 (2.61)			-1.252 (-4.461)	- 1.215 (-4.43)
WARCIV				-0.504 (-2.490)		-0.515 (-2.44)
Adj.-R^2	0.067	0.039	0.199	0.318	0.156	0.196

[3]A full description of the data used can be found in Appendix Three.

2.2.3 Ethnic Divisions and Output

Ethnic divisions are associated with lower output, even after accounting for war. Figure Two shows the relationship between the *ELF* and the log of real GDP per worker in 1990. *(Insert Figure Two Here)* The third and fifth regressions of Table 1 show that both measures of ethnic divisions are associated with lower output.

Ethnic divisions are associated with poverty beyond the damage caused by war. Given that ethnic divisions lead to war and war leads to poverty, some of the poverty experienced by divided nations is due to war. However, accounting for the direct effects of conflict does not account for much of the effect of ethnic divisions on development. The fourth and sixth regressions in Table 1 adds a dummy variable that takes the value one if the country fought a civil war between 1960 and 1990 to the output regressions. The coefficients for ethnic divisions remain significant[4]. This suggests that war itself is not the only reason that ethnic divisions harm development.

2.3 Theory of Ethnicity

What is an ethnic group? Within the context of the model, an ethnic group is a group of people that feel altruistic toward each other and do not feel altruistic toward those outside the group. Members of the group coordinate their actions to benefit each other.

It is difficult to measure altruism. However, it is possible to measure a major source of altruism: the tendency to marry within the group (endogamy). Marriages within a group create a web of family ties. Through this web, familial altruism extends into ethnic altruism. Further, a member of a group may act altruistically toward another member even if there is no contemporary link between them. Since there is a high probability of being linked to other people within the group, a member's actions taken to benefit other members of the group are likely to directly benefit someone she cares about.

Appendix One gives a simple model that illustrates how a high probability of intermarriage leads people to act altruistically toward other members of the group. There are two groups, each with a group specific public good. Parents feel altruistic toward their

[4]Easterly and Levine (1997) do a similar experiment and get similar results.

children and can make contributions to the public goods to benefit them. The appendix shows that labor taxes are distorting if the funding of public goods is centralized and are not distorting if funding of public goods is local.

The intuition is as follows: If the government uses a labor tax on a household to fund a project the household was willing to privately contribute to, the household's decisions are not distorted: The household works the same amount and reduces its contribution to the project to offset the tax. Under local funding, parent's taxes are only used to fund a project they are willing to fund privately. Parents are not willing to contribute to the public good outside their group and centralized funding of public goods forces parents to fund a public good they would not fund privately. Therefore, their labor decisions are distorted.

Endogamy and ethnicity seem to be closely related. Consider the case of the United States. At the turn of the 20th Century, large scale immigration brought a large number of people from a variety of European ethnic groups. At that time, these groups were endogamous (Angrist 2002). Although some vestiges of endogamy remains, Americans of European background are largely indistinguishable in their marriage patterns. The small degree of endogamy within European ethnic groups is dwarfed by the large degree of endogamy among whites compared to other races (Lieberson and Waters 1988). This pattern of endogamy matches feelings of ethnic difference. For example, people of Polish extraction were typically considered to be a separate ethnic group from those of English extraction at the turn of the 20th century. Those feelings are much weaker now, with the descendants of those Polish and English Americans considered to be white Americans. At the same time, those descendants continue to be considered a separate ethnic group from African-Americans.

Are the ethnic groups identified by the *Atlas Narodov Mira* (1964) endogamous, as the theory suggests they should be? The data on ethnic intermarriage is fragmentary. However, I show in those cases where data is available that the Atlas's ethnic groups are generally endogamous. Therefore, I argue that the Atlas's data is close enough to the theory to be meaningful for the empirical work above.

How do we know if a group is endogamous? As a baseline, I will report the expected amount of exogamy (mixed marriages) if matching were completely random. I assume that the number of eligible men and women in a group is proportional to total population and there is no polygamy. I report the probability that a random draw would yield members of different groups.

Table 2 reports the actual and expected levels of exogamy. The details of the calculations are given in Appendix Two.

Table 2: Ethnic Groups and Exogamy

Country (Year)	Pct. Exogamous: Data	Pct. Exogamous: Random Draw
Canada (1971)	45	86.0
Kenya (1989)	7	88.5
N. Ireland (1971)	1.2	47.0
Singapore (1962-8)	5.25	42.0
Singapore (1980-4)	5.9	41.6
Turkey (1993-8)	2.4	23.9
United States (2000)	5.5	40.0
Yugoslavia (1962)	12.7	74.1
Yugoslavia (1989)	13.0	80.2

In each case, the level of exogamy is much lower than would be expected if marriages were random. Clearly, marriage markets are not random. There are a number of factors such as geography, education and wealth that are important in marital choices. However, the gap between the actual and the theoretical levels of exogamy tends to be very large and suggests that ethnicity is an important factor in the choice of marriage partners.

3 Model

3.1 Households

There is a measure one of infinitely lived households divided into two groups. The measure of each group is given by λ_i. The households in each group are altruistic toward each other and are not altruistic to households outside the group. Groups can perfectly and costlessly coordinate their actions in each period. Each group maximizes the average utility of households in the group. The preferences of group i are given by

$$\sum_{t=0}^{\infty} E_t \beta^t \frac{C_i(t)}{\lambda_i},$$

where $C_i(t)$ is group i's consumption of the consumption good in period t. Households are endowed with one unit of labor in each period and have an initial endowment of capital $K(0)$. Throughout the paper, upper case variables indicate aggregate quantities and lower case variables indicate per capita quantities. (For example, $c_i(t) = \frac{C_i(t)}{\lambda_i}$.)

3.2 Government

The government taxes proportion τ of output in each period and gives the revenue to the ruling group. The government is initially controlled by one of the groups, denoted by i^*. The government coordinates its policy with the ruling group and acts in its interests.

3.3 Production

Output Y_i is produced by a technology that uses capital K_i and labor devoted to production $L_{i,P}$ as inputs. Production is given by the Cobb-Douglas function $Y_i = AK_i^{\alpha} L_{i,P}^{1-\alpha}$. Output can be converted into the consumption good and an investment good X_i. The resource constraint is: $C_i + X_i \leq Y(K_i, L_i)$. Next period's capital stock is a probabilistic function of the current period's investment and capital stock, given by the distribution function F. The law of motion on capital is given by:

$$E\ K' = \int \mu\ dF(X, K)$$

There is another technology that produces military arms. It converts labor devoted to the military $L_{i,M}$ into military arms M_i: $M_i = L_{i,M}$. Feasible military spending and labor used in production cannot be larger than the labor endowment: $L_{i,P} + L_{i,M} \leq \lambda_i$.

3.4 War

Groups can attempt to seize control of the government using military arms. They choose whether to fight or concede. The strategy for fighting is given by ϕ_i, the probability that group i fights. The set of groups that are fighting is given by Φ. If the groups fight, the probability that group one wins is given by the function $\pi(M_1, M_2)$:

$$\begin{aligned}\pi(M_1, M_2) &= \tfrac{1}{2} + \tfrac{\kappa}{2}(M_1 - M_2) \\ &= 0 \qquad \text{if } M_2 \geq \frac{1}{\kappa} + M_1 \\ &= 1 \qquad \text{if } M_1 \geq \frac{1}{\kappa} + M_2.\end{aligned}$$

The fighting probability π is a linear function with boundary conditions to assure that π_i is a probability. If a group fights, it loses a portion $\theta \in [0, 1]$ of its output to war damage. If a group wins, they receive the government's revenue for that period. If no group fights the ruling group, the incumbent group receives the revenue.

The winning group may choose who is the incumbent in the next period $i^{*\prime}$. (The group may select itself). Let the strategy ι_i denote the probability group i chooses itself to be the incumbent. Finally, there is a probability $1 - \psi$ the group selected will lose power before the next period begins. This shock is denoted by ξ. If $\xi = 1$, then the selected group retains power. If $\xi = 0$, then the other group is selected. The law of motion on next period's incumbent given ι_i, is given by:

$$\begin{aligned}i^{*\prime} &= i \text{ w.p. } \psi\iota_i + (1-\psi)(1-\iota_i) \\ &= -i \text{ w.p. } (1-\psi)\iota_i + (1-\iota_i)\psi.\end{aligned}$$

3.5 Timing

The timing in each period is as follows:

1. The ruling group chooses M_{i^*}.
2. The other group chooses M_i.
3. The ruling group chooses fighting probability ϕ_{i^*}.

4. Other group chooses fighting probabilities ϕ_i.

5. Based on the vector ϕ, the set of fighting groups Φ is realized. Based on the vector M, control of the government i^{**} is realized.

6. The new ruling group chooses $X_{i^{**}}$.

7. The other group chooses X_i. Next period's capital stock $\{k'_1, k'_2\}$ is realized.

8. The winning group chooses next period's ruling group $\iota_{i^{**}}$.

9. The shock ξ is realized.

There is no private information in the model. Therefore, actions and outcomes of the previous stages of the game are common knowledge.

4 Equilibrium

The interaction of the groups is a dynamic stochastic game. This section describes strategies and payoffs and defines equilibrium.

4.1 Strategies

Let H^t be the set of all histories possible at time t and let h^t be an arbitrary member of H^t. The set of feasible military expenditures for group i is $\mathcal{M}_i$. Let $\mathcal{M} = \mathcal{M}_1 \times \mathcal{M}_2$. The set of fighting probabilities for group i is $\mathcal{P}_i$. Let $\mathcal{P} = \mathcal{P}_1 \times \mathcal{P}_2$. The set of feasible investment expenditures for group i is $\Gamma_i(M, \Phi)$. Let $\Gamma(M, \Phi) = \Gamma_1(M, \Phi) \times \Gamma_2(M, \Phi)$. The set of ι is $\mathcal{I}$.

Due to the sequential nature of the stage game, it is convenient to define strategies in the later stages of a period as functions of previous actions of other players. At the first stage, the strategy is a function of the history. If $i = i^*$ for h^t, then military expenditure is a map $M_{i^*} : H^t \to \mathcal{M}_{i^*}$. For $i \neq i^*$, military expenditure is a map $M_i : H^t \times \mathcal{M}_{i^*} \to \mathcal{M}_i$. Fighting strategies for ruling group are a map $\phi_i : H^t \times \mathcal{M} \to P_{i^*}$. Fighting strategies for other group are a map $\phi_i : H^t \times \mathcal{M} \times \mathcal{P}_i^* \to P_i$. Investment for the winner is given by $X_{i^*} : H^t \times \mathcal{M} \times \mathcal{P} \times \Phi \to \Gamma_i^*(M, \Phi)$. Investment for the other group is given by $X_i : H^t \times \mathcal{M} \times \mathcal{P} \times \Phi \times \Gamma_{i^*}(M, \Phi) \to \Gamma_i(M, \Phi)$. The group selected to be the incumbent in the next period is $\iota : H^t \times \mathcal{M} \times \mathcal{P} \times \Phi \times \Gamma(M, \Phi) \to \mathcal{I}$.

4.2 Payoffs

Due to the sequential form of the games, there are a number of nodes to the game at each stage. I describe the payoffs to strategies at each node. In what follows, take all strategies, aside from the strategy being considered, as given. Denote the vector of strategies by the variable name with the subscript omitted. For example, $M = \{M_1, M_2\}$. I proceed backward from the end of the stage game.

In the final stage, the winner of control of the government i^{**} selects the next period's incumbent. Define $h_t^8 = (h^t, M, \phi, \Phi, i^{**}, X, K')$. Given the strategy $\iota_{i^{**}}$, define $\pi^I = \iota_{i^{**}}\psi + (1 - \iota_{i^{**}})(1 - \psi)$ to be the probability that $i^{*\prime} = i^{**}$. Define $V_i(h^{t+1})$ to be the continuation value for group i, given history h^{t+1}. Given h_t^8, the payoff to strategy $\iota_{i^{**}}$ is

$$\pi^I(\iota_{i^{**}})\beta V_{i^{**}}(h_t^8, \iota_{i^{**}}, i^{**}) + (1 - \pi^I(\iota_{i^{**}}))\beta V_{i^{**}}(h_t^8, \iota_{i^{**}}, -i^{**}). \tag{4.1}$$

In the previous stage, the group that did not win power $(-i^{**})$ chooses its investment. Define $h_t^7 = (h^t, M, \phi, \Phi, i^{**}, X_{i^{**}})$. Define $y_i^F(K, M) = \frac{(1-\theta)Y(K,\lambda_i - M)}{\lambda_i}$ and $y_i^P(K, M) = \frac{Y(K,\lambda_i - M)}{\lambda_i}$. Let $f \in \{F, P\}$ indicate whether a group fought or not respectively. These expressions are the per capita output given a group fighting and not fighting respectively. Given h_t^7, the payoff to strategy $X_{-i^{**}}$ is

$$\begin{aligned} y^f_{-i^{**}} - x_{-i^{**}} + \int\int \pi^I(h_t^7, X_{-i^{**}}, K')\beta V_{-i^{**}}(h_t^7, X_{-i^{**}}, K', i^{**}) + \\ (1 - \pi^I(h_t^7, X_{-i^{**}}, K'))\beta V_{-i^{**}}(h_t^7, X_{-i^{**}}, K', -i^{**})\ dF(X_{-i^{**}}, K_i)dF(X_{i^{**}}, K_{i^{**}}) \end{aligned} \tag{4.2}$$

In the previous stage, the group that won power (i^{**}) chooses its investment. Define $h_t^6 = (h^t, M, \phi, \Phi, i^{**})$. Given h_t^6, the payoff to strategy $X_{i^{**}}$ is

$$\begin{aligned} y^f_{i^{**}} - x_{i^{**}} + \int\int \pi^I(h_t^6, X_{i^{**}}, X_{-i^{**}}(X_{i^{**}}), K')\beta V_{i^{**}}(h_t^6, X_{i^{**}}, X_{-i^{**}}(X_{i^{**}}), K', i^{**}) + \\ (1 - \pi^I(h_t^6, X_{i^{**}}, X_{-i^{**}}(X_{i^{**}}), K'))\times \\ \beta V_{i^{**}}(h_t^6, X_{i^{**}}, X_{-i^{**}}(X_{i^{**}}), K', -i^{**})\ dF(X_{i^{**}}, K_{i^{**}})dF(X_{-i^{**}}(X_{i^{**}}), K_{-i^{**}}) \end{aligned} \tag{4.3}$$

In stage four, the non-ruling group $-i^*$ chooses its fighting strategy. Define $h_t^4 = (h^t, M, \phi_{i^*})$. Define

$$W_i^f(i^{**}) = y_i^f - \frac{X_i}{\lambda_i} + \int\int \pi^I(\cdot)\beta V_i(\cdot, i^{**}) + (1-\pi^I(\cdot))\beta V_i(\cdot, -i^{**})\ dF(X_i, K_i) dF(X_{-i}, K_{-i}),$$

the expected utility for the rest of the game given group i^{**} wins control of the government. The payoff to strategy ϕ_{-i^*} given h_t^4 is

$$\phi_{-i^*}\left(\phi_{i^*}\left[\pi(M)W_{-i^*}^F(1) + (1-\pi(M))W_{-i^*}^F(2)\right] + (1-\phi_{i^*})W_{-i^*}^P(-i^*)\right) + (1-\phi_{-i^*})W_{-i^*}^P(i^*) \quad (4.4)$$

In stage three, the ruling group i^* chooses its fighting strategy. Define $h_t^3 = (h^t, M)$. Given the strategies at future stages of the game, the strategy induces future actions. The payoff to strategy ϕ_{i^*} given h_t^3 is equation 4.4 where $\phi_{-i^*} = \phi_{-i^*}(h_t^3, \phi_{i^*})$.

In stage two, the non-ruling group $-i^*$ chooses its military spending strategy. Define $h_t^2 = (h^t, M_{i^*})$. The payoff to strategy M_{-i^*} given h_t^2 is equation 4.4 where $\phi_{i^*} = \phi_{i^*}(h_t^2, M_{i^*})$ and $\phi_{-i^*} = \phi_{-i^*}(h_t^2, M_{i^*}, \phi_i(h_t^2, M_{i^*}))$.

In the first stage, the ruling group i^* chooses its military spending strategy. The payoff to strategy M_{i^*} given h^t is equation 4.4 where $M_{-i^*} = M_{-i^*}(h^t, M_{i^*})$, $\phi_{i^*} = \phi_{i^*}(h^t, M_{i^*}, M_{-i^*}(h^t, M_{i^*}))$ and $\phi_{-i^*} = \phi_{-i^*}(h^t, M_{i^*}, M_{-i^*}(h^t, M_{i^*}), \phi_{i^*}(h^t, M_{i^*}, M_{-i^*}(h^t, M_{i^*}))$.

Summarize the strategies of group i at t by σ_i^t and the strategies of all groups at t by σ^t. The expected payoff to a group for a strategy profile σ_i, given the initial state and strategies for other groups, is given by $U_i(\sigma_i, \sigma_{-i})$.

4.3 Definition

The equilibrium concept used in this paper is Markov Perfect Equilibrium. In Markov Equilibria, strategies depend only on the state and are independent of time. The state variables are the distribution of capital stocks K and the ruling group at the beginning of each period i^*. Let the state variables be summarized as $s = (K_1, K_2, i^*)$. Let S be the set of states. *Markov strategies* are strategies that map from S instead of H^t. (Strategies are not time dependent.)

Definition 4.1. *A Markov Perfect Equilibrium (MPE) is feasible Markov strategy functions for each group σ_i^* such that:*

1. *For all i, given σ_{-i}^*, $U_i(\sigma_i^*, \sigma_{-i}^*) \geq U_i(a_i(h^t), \sigma_{-i}^*)$ for all feasible strategies $a_i(h^t)$.*

2. *At each node of the stage game, the strategy function maximizes payoff subject to feasibility for all feasible prior actions.*

3. *Laws of motion for the state variables are consistent.*

The first part and third parts of the definition are standard. The second part imposes perfection. Strategy functions must maximize payoffs for all possible previous actions, not just those played in equilibrium.

4.4 Existence

This section establishes the existence of equilibria. The model satisfies the assumptions, aside from some minor differences, of the existence proof in Chakrabarti (1999).

Proposition 4.2. *Assume F is norm continuous. A Markov Perfect Equilibrium exists.*

Proof. The model satisfies the assumptions of Theorem 2 in Chakrabarti (1999), aside from boundedness of the period utility function and state invariant action spaces. Since the state and action spaces are bounded, we can use a modified period utility function $\tilde{u}$ such that for $u < \overline{B}$, $\tilde{u} = u$ and for $u \geq \overline{B}$, $\tilde{u} = \overline{B}$ for some sufficiently large $\overline{B}$. The set of equilibria is the same using the modified utility as using the original. We can further modify the utility function so that $\tilde{u}(s, a) = \underline{B}$ for some sufficiently large negative $\underline{B}$ if a is infeasible in state s. This introduces a discontinuity in the utility function, but this does not affect the upper semi-continuity of the correspondence of period Nash equilibria. □

5 Analytical Results

5.1 Static Model

Bridgman (2002) analyzes the incidence of civil war in a one-shot version of the model similar to the stage game of the dynamic model. I show that war is more likely in ethnically divided countries.

The model in Bridgman (2002) differs slightly from the static version of the dynamic model (that is, when $\beta = 0$). The government is endowed with an amount τ of the consumption good, rather than taxing output. It also considers an arbitrary number I of groups. When I is greater than two, the non-ruling groups move simultaneously. Group one is the incumbent and $k_i = k$ for all i. Finally, the timing is slightly different. Military and fighting decisions are determined at the same time, rather than sequentially.

The main results are replicated here without proof. When $I = 2$, the incidence of war is lower when λ_1 is large. Recall that an increase in λ_1 corresponds to a decline in both ELF and $DIFF$.

Proposition 5.1. *Let* $\frac{(\kappa-1)\tau}{2} > Ak^{\alpha}$. *If* $\phi_1^* = 1$ *and* $\phi_2^* = 0$ *given* λ_1, *then* $\phi_1^* = 1$ *and* $\phi_2^* = 0$ *given* λ_1', *where* $\lambda_1' > \lambda_1$

The proposition states that if there is no fighting when the ruling group is of a certain size, then there is no fighting in cases when the ruling group is larger. The intuition is as follows: War is prevented when the ruling group raises a large enough army to deter the other group from fighting. Therefore, the equilibrium strategies when the outcome is peace are $\phi_i^* = 1$ for some i and $\phi_j^* = 0$ for all $j \neq i$ and when a war is fought they are $\phi_i^* = 1$ for all i. Since the per capita cost of raising an army is lower for large groups, peace (deterrence) is more likely when the ruling group is large.

Next, consider the case when $I > 2$ where the measure of each group is given by $\lambda_i = \frac{1}{I}$. An increase in I is equivalent to an increase in ELF. ($DIFF$ is 1 for all I.) The following proposition shows that the incidence of war is increases as the population is divided into more groups.

Proposition 5.2. *Suppose* $\phi_i^* = 1$ *for all* i, *given some* I. *Then* $\phi_i^* = 1$ *for all* i, *for all* $I' > I$.

As a group becomes smaller, the per capita value of the government's consumption goods increases. Therefore, the non-ruling groups are more willing to fight to control the government. Dividing the population into more groups also diminishes the ruling group's ability to raise an army to deter the other groups. These forces make war more likely when there are more groups.

5.2 Dynamic Model

This section presents analytical results of the dynamic model. I prove a lemma that will be used in the numerical simulations below. I then show that the amount of war fought is not affected by the level of development.

5.2.1 Invariant Distributions

The fighting and investment probabilities in the MPE define a Markov transition matrix. Later, it will be convenient to use the invariant distribution generated by the transition matrix. The following lemma establishes the uniqueness of this distribution.

Lemma 5.3. *If $0 < \psi < 1$, then there exists a unique invariant distribution.*

Proof. Given the investment technology, there is always positive probability of entering a state where $(k_1, k_2) = (k^L, k^L)$. Since $0 < \psi < 1$, there is a positive probability entering a state where $i^* = i$ for $i = 1, 2$. Therefore, Theorem 11.4 of Stokey, et al. (1989) applies. □

5.2.2 Poverty and Conflict

Many observers have suggested that poverty leads to conflict (For example, Grossman and Mendoza (2001)). In the model, poverty does not increase the propensity to fight.

Proposition 5.4. *Let the distribution F be homogenous of degree zero. Let σ^* an equilibrium given $K = (k^L, k^H)$. Then, $\overline{\sigma}$ is an equilibrium for $\overline{K} = (\eta k^L, \eta k^H)$, where $\overline{\sigma} = \sigma^*$ except for $\overline{X}_i(\cdot) = \eta^\alpha X_i^*(\cdot)$.*

Proof. Suppose not. Then there exists for some group a strategy σ' such that

$$U_i(\overline{\sigma}'_i, \overline{\sigma}_{-i}) \geq U_i(\overline{\sigma}_i, \overline{\sigma}_{-i})$$

given $\overline{K}$. Let $\sigma'_i = \overline{\sigma}_i$ except for $\overline{X}_i(\cdot) = \frac{X_i^*(\cdot)}{\eta^\alpha}$. This is a feasible strategy given the original capital stocks K. Since $\pi^K(\overline{X}, \overline{K}) = \pi^K(X^*, K^*)$ and $y(K_i^*, M_i^*) - x_i^* = \eta^\alpha y(\overline{K}_i, \overline{M}_i) - \eta^\alpha \overline{x}_i$, we have

$$U_i(\sigma'_i, \sigma^*_{-i}) = \frac{1}{\eta^\alpha} U_i(\overline{\sigma}'_i, \overline{\sigma}_{-i})$$

Therefore,

$$U_i(\sigma'_i, \sigma^*_{-i}) \geq U_i(\sigma^*_i, \sigma^*_{-i})$$

But then σ^* was not an equilibrium given the original capital stocks K.

□

Increasing the capital stock of the economy does not affect the amount of conflict it exhibits. As the economy becomes richer, the cost of fighting increases because labor time spent in production is more productive. However, the amount of government revenue also increases. These effects offset each other, leaving the amount of conflict in the economy unchanged.

By the same reasoning, increases in productivity do not decrease conflict either.

Proposition 5.5. *Let the distribution F be homogenous of degree zero. Let σ^* an equilibrium given A. Then, $\overline{\sigma}$ is an equilibrium for ηA, where $\overline{\sigma} = \sigma^*$ except for $\overline{X}_i(\cdot) = \eta X_i^*(\cdot)$.*

Proof. The proof proceeds in the same fashion as the proof of the previous proposition.

□

In the model, there is a correlation between conflict and poverty. Divided societies that are prone to conflict also exhibit the investment distortions and resource diversion that reduce income. It is not the case that making a divided society richer will reduce the propensity to fight.

In the data, there is evidence that war causes poverty rather than the poverty leading to war. Stewart, et al. (1997) find that level of development is correlated with incidence of war in the prior decade whereas poverty is not correlated with a civil war being fought in the following decade.

6 Numerical Simulations

6.1 Algorithm

Since equilibrium cannot be fully characterized analytically, I compute the solution numerically. The method I use is value function iteration. The algorithm is:

1. Guess an initial $V_i^0(s)$ for each i.
2. $V_i^{T+1}(s)$ is given by solving the static maximization problem for each state, given $V^T(s)$.
3. Iteration ends when $V_i^{T+1}(s) - V_i^T(s) < \varepsilon$, for all s and i.

6.2 Functional Forms

Before numerically simulating the model, a functional form for the investment technology must be chosen.

To implement the investment technology, I restrict the support of capital stocks to two points, k^H and k^L where $k^H > k^L$. Two points is the smallest support where investment is not trivial. Investment increases the probability that $k' = k^H$.

$$\begin{aligned} k' &= k^H \text{ w.p. } \pi^K(x,k) \\ &= k^L \text{ w.p. } 1 - \pi^K(x,k). \end{aligned}$$

Define $y^P = Ak^\alpha$, the output of a group without war damage or military spending. The probability of having the high value of capital stock is given by $\pi^k(\frac{x}{y^P}) = 1 - \exp(-\nu\frac{x}{y^P})$.

Given that it is not standard, I will discuss the choice of functional form for the investment technology. It was selected to reduce the state space and make the numerical approximation simpler. Given the complexity of the game, using the standard law of motion for capital would have been computationally intensive.

To assure the existence of equilibria, a probabilistic rather than deterministic transition function is required. A deterministic transition function with discrete capital stocks would not be continuous in the actions of the groups, so the existence proof would fail.

Due to the linear preferences, a linear probability function cannot be used. Linear probability function generates the unattractive result that groups are usually in a corner. They either invest or consume all output. For a group to both consume and invest in the same period would require razor's edge indifference between the two activities.

The investment is divided by a measure of output to capture two features of the neoclassical growth model with the standard law of motion for capital. First, the growth rate of capital in the neoclassical model is a function of the investment-capital ratio. At higher levels of capital, more investment is required to maintain the increase in the capital stock. Second, in the one sector growth model, the consumption- and investment-output ratios are unaffected by the level of the capital stock. Dividing by output captures the second feature perfectly. The first feature is captured imperfectly. While capital growth is increasing in the investment-capital ratio, the relationship is not linear.

The measure of output used is not actual output, but potential output: the output when there is no war or military spending. If actual output were used, then there would be an advantage to military spending for investment. Raising a large army would increase the probability of getting a high level of capital.

6.3 Parameters

I now turn to the selection of parameters for the numerical simulations of the model. The investment and production technology parameters are selected to approximate the standard one sector neoclassical growth model. I chose parameters such that the model matches some facts when $\lambda_1 = 1$. I selected Japan as a baseline because it is an ethnically homogenous country with a high level of development. Japan also has a special institutional arrangement where national defense is largely ceded to the United States. Therefore, distortions from military spending to defend against threats from other countries are likely to be small. (According to the 1999 World Development Indicators, Japan spent 1 percent of GNP on the military in 1995.) Following Hayashi and Prescott (2002), I chose parameters to match data from Japan in the 1980s.

The capital share in goods production α and discount factor β are taken from Hayashi and Prescott (2002). The capital stocks k^L and k^H, investment probability parameter ν, and productivity A were selected to minimize the sum of errors (in percentage terms) for three conditions[5]: First, I restrict the parameters such that investing one unit gives an expected marginal increase in capital stock of one unit. This restriction is

$$\sum_s \Pi(s) \frac{\partial \pi^K}{\partial x(s)} (k^H - k^L) = 1.$$

Second, the expected capital-output ratio $\frac{K}{Y}$ is 1.8, and third, the expected investment-output ratio is 0.28. The latter conditions are the period average for Japan from 1984 to 1990.

I set the probability of holding power ψ to 0.95. This represents a five percent a year probability of losing power, the probability of a coup in Africa in the period 1960 to 1982 (Johnson, et al. 1984).

I set the war damage parameter θ equal to 0.04, a four percent drop per year of war. This number was selected on the basis of average annual deviation from trend in countries that have fought civil wars[6]. Deviations of minus one to six percent are observed. (A negative deviation indicates a country grew above trend during war.) Based on the data, a three to five percent annual decline from the onset of war seems to be reasonable.

The parameter τ represents the government's ability to expropriate. It reflects more than just explicit tax rates. Governments in many countries have had institutions and policies that transfer wealth to itself or its clients aside from taxation. These include state owned enterprises, export licensing, and capital controls.

To select a value of τ, I consider the case of Algeria. Algeria has a value of ELF of 0.43, which is close to the maximum of the range covered by the model (0.5). Algeria also fought a civil war. During the 1970s and 1980s, the World Bank (1995) reports that state owned enterprises accounted for about 70 percent of GDP. Government consumption accounts for another 15 percent of GDP. I set τ equal to 0.85.

Algeria was not unique in having having high levels of state intervention. In Sub-Saharan Africa in the period 1966 to 1986, the government employment (government and state owned enterprises) averaged half of formal sector employment. Widespread

[5]Specifically, I set $k^L = 1$ and did a grid search over the remaining parameters.

[6]The results are given in Appendix Four

corruption made control of the government worth more than what is reflected in the official budget. Exportable commodities were often sold through monopsony marketing boards. The boards set purchase prices well below international prices, imposing high implicit taxes on tradable commodities. For a sub-sample of highly interventionist countries, the government employed 71 percent of formal sector labor and agricultural taxation averaged 75.6 percent (Quinn 2002).

I set the parameter in the fighting probability κ equal to 2.5. There is evidence that κ should be large. Hirshliefer (1991) examines evidence on the relationship between the relative size of armies and victory in battles. He finds that having even a small advantage in the army size is associated with winning the battle.

Table 3 summarizes the parameter values used in the baseline simulations.

Table 3: Baseline Parameter Values

α	β	τ	θ	κ	ν	A	k^L	k^H	ψ
0.362	0.976	0.85	0.04	2.5	7.9	1.3	1	4.35	0.95

6.4 Findings

This section discusses in detail a number of implications from the numerical simulations. The most important of these is that ethnically divided countries are poorer. The model is able to generate gaps in income between countries with different levels of ethnic divisions similar to those found in the data.

Table 4 reports simulations for several values of λ_1 using the baseline parameter values given in Table 3. When the value of λ_1 is low, the population is ethnically divided. Therefore, the populations in the simulations toward the right of Table 4 are more homogeneous than those to the left.

In terms of the measures of ethnic divisions described above, a value of λ_1 equal to 0.5 corresponds to a value of 0.5 for ELF and one for $DIFF$. If λ_1 is equal to one, ELF and $DIFF$ are equal to zero.

Results of the simulation are reported as the expected value of variables in the invariant distribution. The results reported are the values of each variable for each state weighted by the probability of being in that state in the invariant distribution.

Table 4: Simulations

λ_1	0.5	0.65	0.75	0.8	0.9	1.0
War	1	0.108	0.070	0.060	0	0
GDP	1.058	1.391	1.4943	1.6971	1.940	2.143
$\frac{X}{Y}$	0	0.003	0.037	0.100	0.200	0.326
$\frac{K}{Y}$	0.945	0.763	1.0099	1.334	1.630	1.873
$\frac{K}{L}$	1	1.045	1.601	2.451	3.325	4.093
Phys. Output	0.802	0.609	0.732	0.946	1.366	2.143

6.4.1 GDP

The first aspect of the simulations that I examine is income. Ethnically divided countries are significantly poorer than homogeneous countries. GDP in the most heterogeneous example ($\lambda_1 = 0.5$) is less than half the level of the least heterogeneous example ($\lambda_1 = 1$). As the population becomes more homogeneous, GDP increases monotonically. Therefore, the model matches the qualitative relationship between ethnic divisions and GDP per capita found in the data.

Moreover, the model is able to match quantitative loss of income due to ethnic divisions. Using the coefficients of the regressions found in Table 1, GDP in the most ethnically divided example is predicted to have a level of GDP that is 63 to 75 percent lower than that of a completely homogeneous country (depending on which measure of ethnic divisions is used). In the simulations, the example where $\lambda_1 = 0.5$ has a level of GDP that is 50.3 percent lower than the example where $\lambda_1 = 1$. Therefore, the model can explain about 70 percent of the decline in GDP per capita associated with ethnic divisions.

Why do ethnic divisions lead to lower levels of income? There are three forces associated with ethnic divisions that lower GDP: War damage, diversion of resources and investment distortions.

First, ethnically divided countries tend to fight more wars. Therefore, these countries lose resources to war damage. In the model, war damage is represented by the loss of proportion θ of goods output.

Second, labor is diverted away from goods production to raising armies. Since ethnically divided counties tend to fight more wars, they divert more resources into armies and away from productive uses.

Third, redistribution causes investment decisions to be distorted. In the most ethnically divided countries, there tends to be a lot of war. This introduces uncertainty about which group will be in power in the future, since the group in power today is likely to overthrown in the future. Since the ruling group changes frequently, households do not know if the proceeds from investment will be expropriated in the future. The risk of expropriation leads households to invest less. In addition, since there is less output due to war damage and resource diversion, there are fewer resources available for investment.

I will analyze how important each of these effects are in accounting for the decline in GDP. Before taking up this issue, I will discuss in detail how GDP is measured in the model. I attempt to use a measure of output that corresponds to the GDP numbers in the data. The measurement of GDP is complicated by the presence of military expenditures. I use the NIPA convention of counting military expenditures as a final good. Using the marginal product for labor in goods production as the wage, military product is wage multiplied by military expenditure M. Since there is no trade between groups, I use faction specific wages. Total GDP is the sum of military product and goods output, weighted by group size. It is possible that one group expends all its labor resources on the military so that there is no implicit wage for that group. When this happens, I use the wage of the other group as the implicit wage.

Table 5 gives a decomposition of the three effects on GDP. The decomposition is calculated by calculating two counterfactual measures of GDP. The first, GDP^D, removes the effect of war damage, while keeping investment and military spending the same. That is, the war damage parameter θ is set equal to zero. The second, GDP^{DM}, removes both the war damage and military diversion effects by setting both θ and M_i equal to zero. Expected GDP in both cases is weighted by the invariant distribution from the fully distorted economy. For the undistorted economy I calculate GDP^{ND}, GDP when $\lambda_1 = 1$. The effect of war damage is given by $GDP^D - GDP$. The effect of military spending is given by $GDP^{DM} - GDP^D$. The effect of investment distortions is given by $GDP^{ND} - GDP^{DM}$.

Table 5: Decomposition of GDP

λ_1	0.5	0.65	0.75	0.8	0.9
Pct. Decline GDP	50.6	35.1	30.3	20.8	9.5
Share of GDP Loss Due to:					
War Damage	3.1	0.3	0.3	0.5	0
Military Spending	19.2	-10.7	-3.8	-0.9	-3.0
Investment	77.7	110.4	103.5	100.4	103.0

Investment distortions account for most of the loss of GDP. Even when fighting occurs with certainty, they account for no less than three quarters of the decline in output. The direct damage and distortions that arise from war are relatively unimportant. In fact, removing military spending may actually reduce GDP. Military spending reduces physical output, which reduces GDP. However, it is counted as a final good, which increases GDP. When the second effect dominates, removing military spending reduces GDP overall.

The possibility of war can reduce output even if no war is fought in equilibrium. While there is no war damage, the distortions that stem from deterrence and redistribution does lower output. This finding is not surprising given that ethnic divisions lower income mostly by distorting investment.

To demonstrate this fact, I run a simulation using the baseline parameters found in Table 3 setting both τ and λ_1 equal to 0.5. The results of this simulation are given in Table 6. When λ_1 is equal to 0.5, there is no conflict observed in equilibrium. (In contrast, war is fought when τ is 0.85.) GDP is 35 percent lower than the ethnically homogeneous economy.

The model is able to account for a quantitatively important part of the decline in GDP per capita even when no war is observed. Using the coefficients of the regressions with a dummy for civil war found in Table 1, GDP in the most ethnically divided example is predicted to have a level of GDP that is 62 to 70 percent lower than that of a completely homogeneous country when no war is fought. The model can explain about a half of this decline.

Table 6: War and Output ($\lambda_1 = 0.5$)

τ	0.85	0.5
War	1	0
GDP	1.058	1.391
$\frac{X}{Y}$	0	0.091
$\frac{K}{Y}$	0.945	1.565
$\frac{K}{L}$	1	1.914

War is prevented when one group deters the other from fighting. Even in peace, resources are used to raise armies. The ruling group must use labor to deter the other group from attempting to seize power. The same forces that make war more likely in ethnically divided countries make deterrence costly in those countries compared to countries that are less divided.

Investment decisions are still distorted when there is peace. First, since resources are diverted from goods production to raising armies, there are fewer resources available to invest. Second, there is little uncertainty about which group will be in power in the future, so the ruling group's investment decisions are not distorted by the possibility of expropriation. However, the non-ruling group knows that it will be expropriated, so its investment decisions are distorted. Since the ruling group is the majority, countries with a large majority are less distorted by redistribution than countries with a smaller majority.

In contrast to GDP, production of consumption and investment goods (physical output in Table 4) is not necessarily monotonically increasing in λ_1. A highly divided country that fights wars may have higher physical output than a less divided country. The reason for this is that an army used to deter may need to be larger than one used to fight. It is obvious that the army required for deterrence is larger than an army in a case where a war is fought for a given level of ethnic divisions. It may be the case that the army required for deterrence in a somewhat less divided country is larger than the armies used to fight a war. The larger army can large enough to offset the fact that non-ruling groups are not spending on the military and there is no war damage. It is still rational for the government to deter in this case since the decline in output is borne by the non-ruling group. That is, getting all of a small pie is better than getting a piece of a larger pie. However, a completely homogenous nation always has the largest output.

6.4.2 War

I now examine the relationship between ethnic divisions and war. When λ_1 is higher, the amount of war observed in equilibrium declines. Therefore, more ethnically divided countries are more likely to fight a civil war. This relationship matches the empirical relationship between civil war and ethnic divisions.

The basic intuition for this result is the following: In the model, peace occurs when one group raises a large army to deter the other group from fighting. Large groups able to raise armies more easily than small groups, so peace (deterrence) is more likely when a country is more homogeneous.

Since fighting success depends on the total military resources and labor is the only input in the military technology, a large group can raise a large army just by virtue of its size. It is also less costly for a large group to raise an army. When λ_1 is large, the per capita labor requirement to raise an army of a given size is small for group one compared to that of group two. Since the production function for output is concave in labor, the lower per capita labor requirement implies a lower marginal cost to raising an army.

Since large groups can easily raise armies, it is relatively easy for the group one to deter group two when group one is large. When the groups close to the same size, deterrence is more costly. Raising armies is more costly for the majority and less costly for potential rivals. Therefore, war is more likely when a country is ethnically divided.

Having the groups move sequentially allows the ruling group to commit to deterrence when it would not be able to in a simultaneous move game. If the groups moved at the same time, it would not typically be a best response for the ruling group to raise an army to deter the other group if the other group did not raise an army. If the ruling group raises a large army, the non-ruling group will not spend on the military and concede. However, it the non-ruling group is not raising an army, the ruling group would want to deviate to a smaller army. Nash equilibrium in the simultaneous game usually requires that both groups raise armies and fight.

Variables in the simulations are reported as weighted sums in the invariant distribution, but it is instructive to examine some of the policy functions. When λ_1 equals 0.5, the groups fight no matter who is in power. The groups are evenly matched, which makes deterrence very costly. When λ_1 equals 0.75, the groups fight only when group two is in power. It is too costly for group two to deter group one. However, the loss due to war damage is smaller than benefit of having a small chance retaining power. Since group one deters group two, group two only gains power through coups (the ξ shock). Finally, when λ_1 equals 0.9, war is never observed in equilibrium. Even when group two is in power, it chooses to concede power. Group one is so large that group two cannot deter it. If group two fought, it would have such a low probability of winning that it concedes. In this case, group one prefers to have group two in power so group one returns power at the end of the period.

Since the parameters τ and κ are not standard, it is of interest to check the robustness of the results to different values of these parameters.

Higher values of τ generate higher levels of conflict in equilibrium. This fact is demonstrated by the simulations reported in Table 6. A decline in τ is associated with a decline in war. The intuition for this is obvious. As the value of controlling the government increases, groups are more willing to fight for control. Therefore, deterrence is more difficult for the government.

For low levels of κ, it is possible generate conflict in less ethnically divided countries. Thus there exist parameters that generate the opposite relationship between ethnic divisions and conflict. The decision to fight is determined by the benefits and costs of fighting. For a small minority, it is costly to raise an army. However, the per capita value of seizing control of the government's revenues is very high. The parameter κ determines the cost of fighting. When κ is very low, the chance of winning in relatively unaffected by the relative sizes of the groups' armies. Therefore, the cost of fighting is very low while the benefits are very high for the small group. Deterrence of the minority is difficult for the majority in this case. For moderate values of τ, the majority will choose to fight rather than deter the minority or concede control of the government. (For very low levels of τ (e.g. zero) , the value of the government is too low to fight over.)

6.5 Foreign Aid and War

There has been a great deal of disappointment with the ability of foreign aid to improve the level of development. Drazen (1999) surveys the evidence on aid effectiveness. Aid is not associated with higher growth or investment rates and is associated with increases in government consumption.

The model indicates that ethnic divisions can reduce the effectiveness of foreign aid. Typically, aid is given to the government, increasing the resources available to the government for redistribution. Therefore, the redistributive value of the government is higher and groups are more willing to fight to control it. Some of the resources that aid brings may be dissipated by an increase in rent seeking[7].

Table 7 reports simulations for a different levels of foreign aid. The parameters are the baseline parameters with τ and λ_1 is set to 0.5. The table compares the equilibrium under different level of aid. Aid is given is to the government in the form of homogenous output. Formally, aid becomes available to the government in each period after the control of the government is determined (stage five of the stage game). Aid may be consumed or invested. Income is reported in two ways: Income from domestic production (GDP) and income including the aid (GDP + Aid). I use GDP as the denominator in the investment- and capital-output ratios.

Table 7: Foreign Aid and War

Aid	0	1
War	0	1
GDP	1.391	1.264
GDP + Aid	1.391	2.264
$\frac{X}{Y}$	0.091	0.054
$\frac{K}{Y}$	1.565	1.361
$\frac{K}{L}$	1.914	1.824

The simulations show how ethnic divisions can reduce the effectiveness of aid. Total income (GDP + Aid) goes up by less than the amount of the aid: There is an

[7]Svensson (2000) and Grossman (1992) make this point.

actual absolute increase of 0.87 with 1 unit of aid. Aid increases the relative payoff to fighting for control of the government relative to investment. Groups divert resources to fighting away from investment to military spending. The investment-output ratio decreases despite having the aid available for investment. In contrast, aid to ethnically homogeneous nations do not induce an increase in rent seeking and none of the aid is wasted.

Aid can induce civil war in a country that would not fight without the aid. In this case, the aid increases the redistributive value of the government to such a degree that groups are now willing to fight. Grossman (1992) presents an economic model of civil war where foreign aid can increase the amount of resources devoted to fighting. In this paper, foreign aid can induce a country to fight that would not fight without the aid.

7 Conclusion

Ethnically divided countries tend to be poorer than homogeneous countries. This paper presents a model that can account for most of the gap in income between ethnically homogeneous and ethnically divided countries. In addition, the model can explain the relationship between ethnic divisions and civil war.

An obvious avenue for future research is to add additional groups. The dynamic model is only analyzed for the two group case. The maximum value of ELF that can be achieved with two groups is 0.5 while much higher values are observed in the data. (The highest in the sample is Tanzania with 0.93.) Getting values of ELF that high require more groups. The analytical results for the static version of the model with two groups extend to the dynamic model, suggesting that the results for multiple groups may also extend to the dynamic case. However, more research is required to confirm this conjecture.

The model is a useful step toward building a theory of nations. There is an active literature discussing the optimal size and number of nations (See Alesina (2002)). There is tradeoff between returns to scale and heterogeneity. Large nations have an advantage in providing public goods such as national defense and benefit from a large internal market. On the other hand, large nations are more likely to have disparate preferences over government policy. This paper discusses an important source of this heterogeneity. Successful countries are those that have a dominant majority ethnic group.

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A Appendix One: Intermarriage Model

A.1 Model

Environment

There is a single time period. There are $2N$ households that live in one of two locations: L_1 and L_2. There are two types of households: parent and child households. N households are parent households and N households are called child households. $\frac{1}{2}N$ of each type of households are in each of two locations. The set of households in location L_k of type $t \in P, C$ is I_k^t for all k, t. There is a local public good in each location. The amount of public goods at L_k is G^k.

Households

Parent households have preferences over their own consumption, labor and the consumption of private and public goods of a child household. Parent households must make their decisions before they know which household will be their child household and choose their actions to maximize expected utility. Let k denote the location of a household and $-k$ denote the other location. The probability that a parent household is linked with one of the households in the same location is $\Pi^k = \frac{1}{\frac{1}{2}N}$. The probability that a parent household is linked with one of the households in the other location is 0. Parent households can make bequests to child households (b_{ij}) and contribute to the public goods (g_i^k). Preferences for parent households are represented by the utility function

$$EU_i = u(c_i^1, l_i) + \sum_{j \in I_k} \Pi^k v(c_j^2, G^k) + \sum_{j \in I_{-k}} \Pi^{-k} v(c_j^2, G^{-k})$$

Child households have preferences over their consumption of private consumption and of the local public good in their location. They receive an endowment ω of the consumption good. Child household j's preferences at location k are given by $v^C(c_j^2, G^k)$. (Note that v need not be that same as v^C.)

Government

There is a government that taxes parent households' labor income and funds public goods. It has access to both lump sum taxes T_i and proportional taxes τ_i. The government's funding of public goods is given by g^k. The government's budget constraint is

$$g^1 + g^2 = \sum_i T_i + \sum_i \tau_i l_i$$

A policy is a tax schedule and spending rule for public goods (a map from the amount of revenue raised to the amount of each public good funded).

Game

The game proceeds as follows:

1. Government announces its policy.
2. Parent households simultaneously choose labor effort, public goods contributions, bequests and consumption.
3. Parents are linked to a child household.
4. Child households choose consumption and public goods.

A.2 Equilibrium

The equilibrium concept I use is Subgame Perfect Equilibrium. Given a policy, parent household choices and other child household's decisions, the best response for a child household $j \in I_k^C$ is:

$$\begin{aligned} BR_j = &\text{argmax}_{c_j, g_j^1, g_j^2} v^C(c_j, G^k) \\ \text{s.t. } &\omega + \sum_i b_{ij} \geq c_j + g_j^1 + g_j^2 \\ &G^k = g_j^k + \sum_i g_i^k + \sum_{j' \neq j} g_{j'}^k + g^k \end{aligned}$$

Given a policy, child household's best responses and other households' choices, a parent household's best response is given by:

$$
\begin{aligned}
BR_i = & \text{argmax}_{c_i, l_i, \{b_{ij}\}, g_i^1, g_i^2} \left\{ u(c_i, l_i) + \sum_{j \in I_1} \Pi^1 v(c_j, G^1) + \sum_{j \in I_2} \Pi^2 v(c_j, G^2) \right\} \\
& \text{s.t. } l_i - T_i \geq c_i + \sum_j b_{ij} + g_i^1 + g_i^2 \\
& \quad G^k = g_i^k + \sum_{i' \neq i} g_{i'}^k + g^k + \sum_j g_j^k(\cdot)
\end{aligned}
$$

Summarize strategies for parent household i by $\sigma_i = \{c_i, l_i, \{b_{ij}\}, g_i^1, g_i^2\}$ and for child household j by $\sigma_j = \{c_j, g_j^1, g_j^2\}$.

Definition A.1. *A Subgame Perfect Equilibrium for a given policy is parent strategies $\{\sigma_i^*\}$ and child strategies $\{\sigma_j^*\}$ such that:*

1. *Given parent strategies, for each child household $\sigma_j^* \in BR_j(\{\sigma_i^*\}_i, \{\sigma_j^*\}_{-j})$*
2. *For each parent household $\sigma_i^* \in BR_i(\{\sigma_i^*\}_{-i}, \{BR_j\}_j)$*

A.3 Results

I compare the results under two spending policies. The first is local spending. Taxes raised in each location are used to fund only the local public good. The second is centralized spending. Taxes are put into a common pool and each local public good is funded from this pool. I show that labor taxes under centralized spending are distorting while they are not under local spending.

Under local taxation, if all parent households contribute to the local public goods, proportional labor taxes are not distorting[8].

[8] The proof follows Bernheim and Bagwell (1988).

Proposition A.2. *Suppose $g_i^k > 0$ for all i, given tax schedule $T_i \geq 0$ and $\tau_i = 0$ for all i and spending policy $g^k = \sum_{i \in I_k^P} T_i$. Let c_i^*, l_i^* and $G^{1,*}, G^{2,*}$ be the equilibrium allocation. Then $\{c_i^*, l_i^*\}$ and $\{G^{1,*}, G^{2,*}\}$ is an equilibrium under the tax schedule $\tau_i = \frac{T_i}{l_i^*}$ and $T_i = 0$ for all i and spending policy $g^k = \sum_{i \in I_k^P} \tau_i l_i$.*

Proof. The proof proceeds by showing that the choice set of the household is the same under each tax scheme aside from a non-binding constraint. Let $\overline{BR}_i$ and BR_i be the best response correspondences under the lump sum tax scheme (problem one) and proportional tax scheme (problem two) respectively given that all other households are playing $\left\{c_i^*, l_i^*, g_i^{k,*}\right\}$. I show that $\overline{BR}_i = BR_i$ for all i. Since child households are not paying taxes, their best response in unaffected. Consider parent households. Fix other households' actions. Define $\gamma_i^k = T_i + g_i^k$. This is total resources from the household going to public good k. The constraints for problem one can be rewritten with γ_i^k as the choice variable:

$$
\begin{aligned}
l_i &\geq c_i^t + \sum_j b_{ij} + \gamma_i^1 + \gamma_i^2 \\
G^k &= \gamma_i^k + \sum_{i' \neq i} \gamma_{i'}^k \\
& \gamma_i^k \geq T_i
\end{aligned}
$$

There is now an additional constraint, but since $g_i^k > 0$ it does not bind. The constraints for problem two can be rewritten in a similar fashion. Define $\overline{\gamma}_i^k = \tau_i l_i + g_i^k$. The constraints can be rewritten in exactly the same way. However, the constraint $\gamma_i^k \geq \tau_i l_i$ now depends on l_i. This constraint does not bind. To see this, note that the two problems are the same if the final constraint is omitted. Since the final constraint does not bind in problem one, the only way for the best responses to be different is if the final constraint binds in problem two. It does not bind because $\tau_i = \frac{T_i}{l_i^*}$. Since this argument applies to all households, the conclusion follows.

□

A similar result can be proved for redistribution between parent and child households when $b_{ij} > 0$ for all i, j in a location.

This neutrality result fails when public goods spending is centralized. This is illustrated in the following simple example.

Example

Let $N = 2$. Household one is located at L_1 and two at L_2 ($i = k$). The preferences of the parent households are given by:

$$EU_i = log(c_i) - \alpha l_i + \beta log(G^i)$$

With these preferences, it is clear that $b_{ij} = 0$ for all i and $g_i^{-i} = 0$ for $i = 1, 2$ in equilibrium.

Consider two policies. Under policy one, the government taxes each parent household lump sum T and spends T on each public good ($g^i = T$). Under policy two, the government taxes each parent household using proportional labor tax τ and spends half of its revenue on each public good ($g^i = \tau(l_1 + l_2)$).

The equilibrium under the first policy is:

$$\begin{aligned} c_i^* &= \frac{1}{\alpha} \\ g_i^{i,*} &= \frac{\beta}{\alpha} - T \\ l_i^* &= \frac{1+\beta}{\alpha}. \end{aligned}$$

The equilibrium under the second policy is:

$$\begin{aligned} \bar{c}_i &= \frac{1 - \frac{\tau}{2}}{\alpha} \\ \bar{g}_i^i &= (\frac{(1+\beta)(1-\tau) - 1}{\alpha})(1 - \frac{\tau}{2}) \\ \bar{l}_i &= \frac{1+\beta}{\alpha}(1 - \frac{\tau}{2}). \end{aligned}$$

Setting $\tau_i = \frac{T_i}{l_i^*}$ yields $\bar{l}_i = \frac{1+\beta}{\alpha}(1 - \frac{T}{2})$. The two policies are not equivalent.

This result holds even when there is a positive probability of being linked to a child household in the other location. In fact, with functional forms used in the example, only under perfect mixing ($\Pi^1 = \Pi^2$) do parent households make contributions to both goods. To see this, note that by symmetry $G^1 = G^2$. For both $g_i^i, g_i^{-i} > 0$, $\frac{\Pi^k}{G^i} = \frac{\Pi^{-k}}{G^{-i}}$. This is only true if $\Pi^1 = \Pi^2$.

Appendix Two: Intermarriage Data

This appendix reports the the details of the intermarriage data used in Table One.

Canada Richard (1991) examines marriage data from the 1971 Census. Marriages are classified by the national origin and nativity of the husband. The *Atlas's* data only refers to nativity for people of English and French decent. The expected level of exogamy using the *Atlas's* definitions is 86.0 percent. Actual exogamy is 45 percent.

Kenya Ezeh (1997) examines data from the 1989 Kenya Demographic and Health Surveys (KDHS1). "In the subsample of couples in the KDHS1, 93 percent of husbands and wives report the same ethnic origin; this proportion increases to 95 percent when foreigners and those with unspecified ethnicity are excluded." (p. 358) Ezeh (1997) does not report population by ethnicity for the KDHS1 sample, which does not have full national coverage. Using 1989 Census data, the expected exogamy rate is 88.5 percent. The ethnic groups in the survey are identified as separate ethnic groups in the *Atlas's* data. (The *Atlas* names refer to the own language names whereas Ezeh uses the Westernized names. For example, the Atlas uses Joluo while Ezeh uses Luo. The conversions are given in Berg-Schlosser (1984).)

Northern Ireland Lee (1994) analyzes marriages between Catholics and Protestants (Scotch-Irish in the *Atlas*) using data from the 1971 Northern Ireland Census. In 1.2 percent of marriages were interfaith. The expected level of exogamy using population data is 47.0 percent.

Singapore Hassan and Benjamin (1976) analyze data from Singapore's Registrar-General of Births and Deaths. Over the years 1962 to 1968, 5.25 percent of new marriages were exogamous. Based on 1967 population data, the expected level of exogamy is 42.0 percent. Some ethnic categories in their study are aggregations of the *Atlas's* groups. For example, "Indian-Pakistani" is divided into subgroups (Punjabi, Bengali, etc.) in the Atlas data.

Lee (1988) studies data from Singapore's Department of Statistics. For the period for 1980 to 1984, 5.9 percent of marriages were exogamous. The expected level of exogamy is 41.6 percent. Some ethnic categories in their study are aggregations of the *Atlas's* groups.

Turkey Gunduz-Hosgor and Smits (2002) study data from the Turkish Demographic and Health Surveys in 1993 and 1998. They only consider Turks and Kurds and do not report the populations of other groups. They find that 2.4 percent of marriages were exogamous. The expected level of exogamy is 23.9.

United States According to Current Population Survey, 5.5 percent of marriages in 2000 were between partners of different races. Based on 2000 Census data for people of one race, expected exogamy is 40.0 percent.

Yugoslavia Botev (1994) analyzes marriage data from Yugoslavia's Federal Statistical Office for the years 1962 to 1989. He finds that "between 12 and 13 percent of marriages in Yugoslavia as a whole are mixed, with little variation over time." (p. 468) He concludes that "ethnic endogamy has been the norm in Yugoslavia." (p. 476) The expected level of exogamy under random matching is 74.1 percent in 1962 and 80.2 percent in 1989. The ethnic categories in his study are the same as those of the Atlas. (Botev includes "Moslems" and whereas the *Atlas* refers to this group as "Bosnians.")

Appendix Three: Data

This appendix reports sources and definitions of data used in the paper.

ELF Ethnolinguistic Fractionalization: Easterly and Levine (1997).

CWYRS Years of Civil War, 1960-1995: Sivard (1996).

WARCIV Dummy for Civil War, 1960-90: Sivard (1996).

LGDPW90 Log of Real GDP per Worker: Penn World Tables.

Appendix Four: War Damage

This appendix reports the results of the deviations from trend caused by protracted civil wars. The countries are the sample analyzed in Stewart, et al. (2001), table 4.16. The data used is Real GDP per Worker, from the Penn World Tables. This deviation was calculated in the following way: First, I estimate a linear trend in output per worker in the pre-war period by taking an average of annual growth rates. Then, I use this trend to extrapolate output from the last pre-war observation out to the end of the war period or the end of the available data. The average annual deviation is the percentage decline of actual output from the trend series divided by the number of years of war.

Table 8: War Damage

Country	War Years	Avg. Pct. Annual Deviation
Angola	1975-95*(89)	5.71
Burundi	1988-95*(90)	-1.10
Ethiopia	1974-86	0.01
Mozambique	1981-90	-0.11
Somalia	1988-95*(89)	5.36
Sudan	1984-95*(90)	3.33
Uganda	1971-87	2.27
El Salvador	1979-91*(90)	4.94
Nicaragua	1978-88	6.40

*Data ends before end of civil war. The number in parenthesis gives end of data sample.

Figure One:
Average Years of Civil War Sorted by ELF Deciles
1960-1995

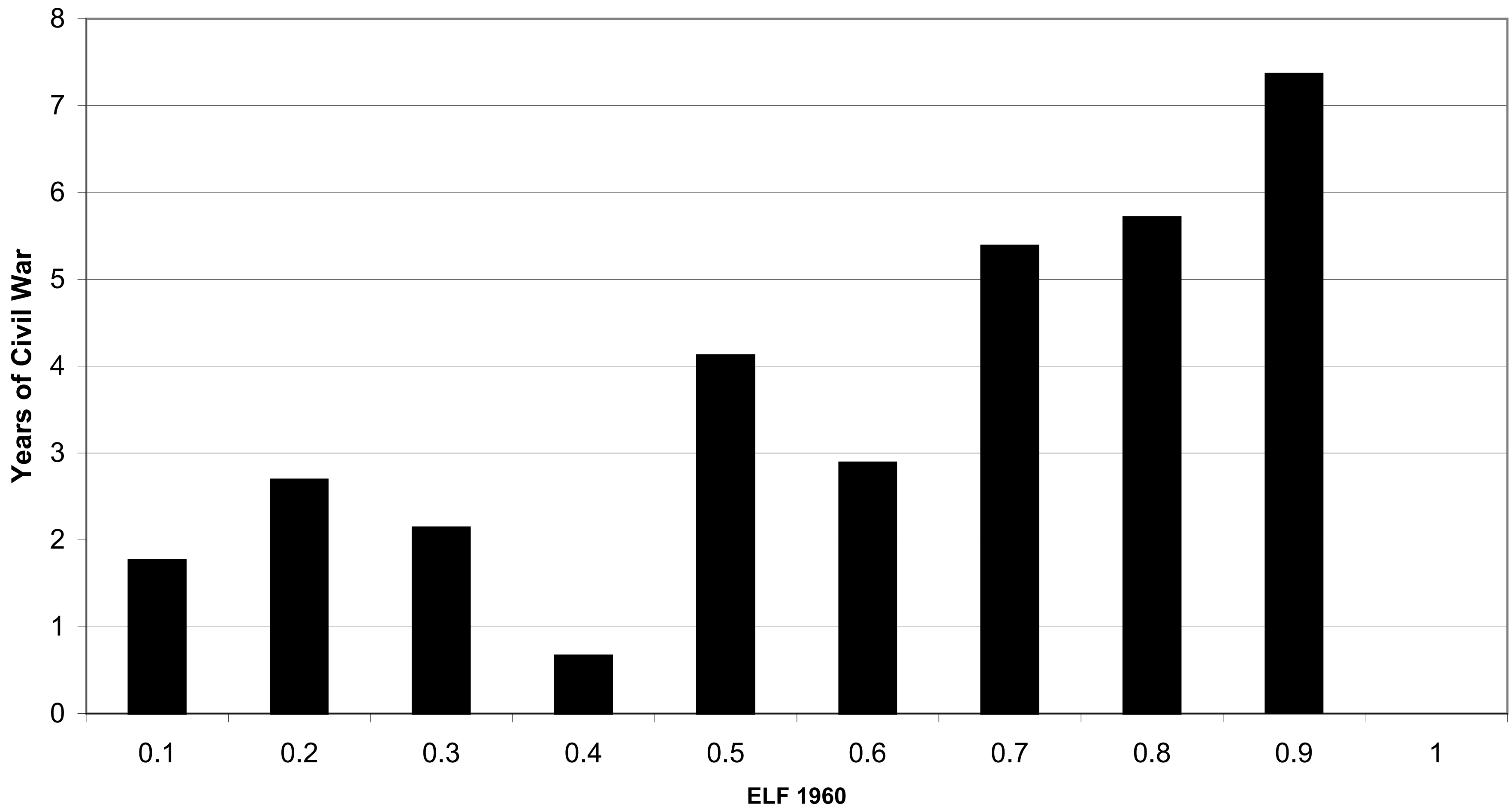

Figure Two:
Log GDP per Worker and ELF