ETHNICITY, COMMUNICATION AND GROWTH¤

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In this paper we consider the link often alleged between ethnic diversity and the growth rate of GDP per capita. We hypothesize that the impact of ethnic diversity on growth may depend on communication costs. This leads us to estimate a traditional growth rate equation on cross sectional data in a switching regression framework. In "low communication costs countries", the relationship between growth and ethnic diversity is U-shaped, which corresponds to ethnic polarization, rather than fragmentation, constituting the major impediment to growth. On the other hand, in "high communication costs countries", growth is a decreasing function of ethnic diversity and the severity of the latter's deleterious impact is an increasing function of communication costs, proxied here by the illiteracy rate. The regime that a country belongs to is a function of two proxies for communication costs: the illiteracy rate and population density. The impact of ethnic diversity on growth seems not to operate through macroeconomic policy choices. Rather it is a direct transmission mechanism, in which ethnic diversity affects private and public ressource allocation, that appears to dominate.

I. Introduction

Several recent cross-sectional studies in economics have underlined the role of ethnic factors as determinants of the growth performance of developing countries. Mauro (1995), for instance, considers ethnic fragmentation to be a determinant of corruption which in turn may have a negative impact on growth. Collier and Hoeffler (1998) focus on the role of ethnic diversity in triggering civil war. Easterly and Levine (1997), as well as Temple (1998) argue that ethnic fragmentation leads to poor policies that, in turn, affect growth performance. This explains, according to these authors, the relatively poor growth performance of subsaharan Africa. At the outset, it should be noted that several other studies do not confirm the importance of ethnic diversity in cross-country growth regressions (Sachs and Warner, 1997, Rodrik, 1998, Guillaumont, Guillaumont Jeanneney and Brun, 1998).

The empirical finding that ethnic diversity influences growth raises many questions, not the least of which is what to do about it from the policy perspective. The purpose of this paper is not to contest the fact that ethnicity may play an important role as a determinant of growth. Rather, we wish to investigate *how* ethnicity affects growth. This paper thus considers three issues.

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First, the current literature has been almost exclusively focused on ethnic *diversity*.[1] We argue that polarization may also constitute a fetter on growth. This is why we use the term "ethnicity" rather than "ethnic fragmentation".

Second, we consider different transmission mechanisms through which ethnicity may affect growth. These may be divided into two categories : (i) direct mechanisms, in which ethnicity affects the allocation of ressources by private or public agents, and (ii) indirect mechanisms in which the impact of ethnicity on growth is mediated through its impact on macro policy choices. It is interesting from the empirical perspective to ascertain which of these two transmission mechanisms is in fact operative. Moreover, we posit that ethnicity does not affect growth in a uniform manner across countries. Rather, its impact on growth depends on the ease with which different social groups are able to communicate with each other, as might be measured by such indicators as literacy or population density.

Third, we test these hypotheses using a two-regime switching regression model of the determinants of growth that distinguishes between countries that are weakly integrated and where communication costs are high, *versus* those where the opposite is true.

II. Fragmentation *versus* Polarization

Given that it is the deleterious impact of ethnic divisions that has been the focus of the recent literature on ethnicity and growth, it is perhaps not surprising that the empirical measure of choice has been an indicator of ethno-linguistic fragmentation, constructed by Taylor and Hudson (1972) on the basis of data published by Soviet geographers at the beginning of the sixties. This indicator (which is by now denoted by most researchers as ELF or $ELF60$) is defined as follows :

$$ELF = 1 - \sum_{i=1}^{i=n} \left(\frac{x_i}{N} \right)^2 ,$$

where x_i is the number of people in the i th ethnic group, $N = \sum_{i=1}^{i=n} x_i$ is the total population and n is the number of ethnolinguistic groups in the country; ELF thus measures the probability that two randomly selected persons from a given country will not belong to the same ethnolinguistic group.[2]

[1] Collier and Hoeffler (1998) and Temple (1998) constitute an exception to this tendency.
[2] Mauro, 1995, p. 692.

The point we wish to raise concerns the distinction between ethnic *diversity* and ethnic *polarization*, two concepts that are often equated but that are in fact quite distinct. Let $\bar{x}$ denote the mean size of the ethnic groups, and let s^2 denote the variance of the size of the ethnic groups. Then it can be readily shown that we may re-express ELF as :

$$ELF(n, s^2, \bar{x}^2) = 1 - \left(\frac{s^2 + \bar{x}^2}{n\bar{x}^2} \right) = 1 - n^{-1}\left(1 + c^2\right),$$

where $c = s / \bar{x}$ is the coefficient of variation. Five comments are in order regarding this measure. First, it is immediate that, for a homogeneous population made up of a single ethnic group, we will have $n = 1$, $s^2 = 0$ and thus $ELF(1,0,\bar{x}^2) = 0$. Second, for a population made up of n ethnic groups of identical size, we will have $s^2 = 0$ and $ELF(n,0,\bar{x}^2) = 1 - n^{-1}$. Third, when one moves from a situation with a single ethnic group to a situation with two ethnic groups of equal size, the measure of ethnic diversity goes from 0 to 0.5. Fourth, consider the two following hypothetical distributions of ethnic groups : one group makes up one half of the population and five other equally-sized groups constitute the rest. The corresponding value of the measure of ethnic diversity is $ELF =$ 0.67. Fifth, the same value is obtained with three ethnic groups of equal size.

It is important to note that the third case, two ethnic groups of equal size, corresponds to what one might term extreme "polarization", and polarization is not necessarily more favorable, in our view, to increasing the growth rate of per capita GDP than is the situation described in the fourth or the fifth case, despite the fact that the indicator of ethnic fragmentation is larger in the fourth or fifth case (0.67) than in the polarized case (0.5).

An operational definition of polarization would be that it corresponds to a situation where the probability of confrontation between ethnic groups is high. This is manifestly the case when there are two ethnic groups of equal size. But it is also the case when there is one dominant group and several smaller groups likely to form a coalition that is capable of opposing the dominant group.

It is intuitively appealing that the maximum level of ethnic polarization is reached when there are two ethnic groups of equal size. In this case, ELF equals one half. It is also intuitively appealing to assume that any measure of ethnic polarization will be smaller than the previously defined maximum for any other configuration of ethnic groups, and thus, at least locally, for any value of ELF that is different from one half. Rather than assuming a particular form for what would be a necessarily arbitrary definition of polarization, we prefer to characterize ethnic polarization in the following manner :

Definition. Any workable definition of ethnic polarization, $P \in [0,1]$, must satisfy the following condition, as a function of ethnic diversity ELF :

$$\text{For } P = P(ELF), ELF \in [0,1], P \in [0,1]: \arg\max_{\{ELF\}} P(ELF) = \frac{1}{2};$$

By the usual argument in terms of a second-order Taylor expansion, such a function may be locally approximated (around $ELF = 0.5$) by a quadratic polynomial. This implies that, if one plots ethnic polarization on the vertical axis *versus* ethnic fragmentation on the horizontal axis, the result is an inverted U-shaped curve that reaches its maximum at $ELF = 0.5$ and displays its minimum value at $ELF = 0$ and $ELF = 1$.

Thus, if it is polarization, rather than diversity *per se*, which constitutes the hindrance to growth, a decrease in the degree of ethnic fragmentation will not necessarily increase the growth rate of per capita GDP. Indeed, if one posits an unambiguously negative relationship between the degree of polarization and per capita GDP growth, the inverted-U-shaped relationship between polarization and ethnic fragmentation (with polarization reaching a maximum for a value of the ethnic fragmentation variable equal to one half) induces a U-shaped relationship between ethnic fragmentation and the growth rate of per capita GDP.

The precise shape of the relationship is not critical here. What is critical is to focus one's attention on the fact that the relationship between ethnic diversity and the growth rate of per capita GDP may not be a linear one, in part because ethnic diversity may be a rather poor proxy for more important factors such as polarization. Indeed, our argument here squares rather nicely with that put forward in a recent paper by Collier and Hoeffler (1998) and by Temple (1998), who argue that polarization corresponds to a situation in which the index of ethnic fragmentation lies in the middle range. Such a configuration, according to Collier and Hoeffler (1998), increases the probability of violent conflict among ethnic groups, namely, the probability of civil war. Our view, however, differs from that of the preceding authors in that we allow for different ethno-economic scenarios as well as for different transmission mechanisms running from ethnicity to growth.

III. Transmission Mechanisms

There are several ways in which ethnicity might affect growth. Relying on what has been suggested in recent work, we divide the existing arguments into two categories : transmission mechanisms in which ethnic concerns have a direct impact on the growth rate of per capita GDP as far as it renders the allocation of resources less efficient, *versus* indirect mechanisms in which the effect of ethnicity on growth is mediated through some intermediate (usually macroeconomic policy) variables. More importantly, we suggest that the nature of the relationship between ethnicity and growth depends upon communication costs within the country. Thus, a given level of ethnicity may impact growth differently, depending upon the communication costs regime in which the country finds itself.

Direct and Indirect Transmission Mechanisms

One manner in which ethnicity may affect the growth rate of per capita GDP is through its direct impact (i.e., not mediated through macro policy variables) on the allocation of private or public resources within the economy. There are several mechanisms through which this direct effect may operate.

The private or public allocation of investment projects on the basis of ethnically-derived formulae that are often divorced from rate of return considerations will tend to move the economy away from the efficient frontier. Similarly, discrimination in hiring practices based on ethnic concerns rather than competence may, for instance, result in an inefficient allocation of human capital. Both cases illustrate that ethnicity may lead to market segmentation.

The distortion in resource allocation is exacerbated when there exists ethnically-based specialization of activities. For instance, in Niger, Haousa are devoted to trade and production whereas Djerma make up the civil service. Such a form of specialization induces an inefficient allocation of talent, as well as a plethora of civil servants. In many other countries, small trading activities are fulfilled by foreign minorities (such as Indians in Madagascar and in East Africa) ; the result is that, following political disturbances that involve the minority, markets may be disrupted and trade may become more costly and uncertain.

Another mechanism through which ethnicity impacts the growth rate is linked to the hindrance it imposes on consensus-building related to public expenditures in social sectors. Such lack of consensus may be particularly important when it comes to the provision of those public goods that promote economic growth. The classic example would be the efficiency of the educational system, which is likely to be severely impaired when there is no consensus as to the language of instruction, the content of the curriculum, or the geographical location of facilities. The same might be said of infrastructure construction, which will be a function of the geography of the underlying ethnic groups and will not necessarily be based upon productivity-enhancing concerns. This effect associated with ethnicity might be labeled as the "public good provision" effect.

As an extreme example of the direct transmission from ethnicity to resource allocation, ethnic diversity can also result in political instability and violence that reduce the level of productive private investment (Collier and Hoeffler, 1998), and the productivity of both public and private investment.

An alternative hypothesis is that ethnic diversity affects the growth rate of GDP per capita through its impact on the pursuit of macroeconomic policies conducive to growth. The mechanism through which the indirect effect of ethnic diversity makes itself felt is that it encourages the adoption of policies associated with rent-seeking activities (Mauro, 1995). Since these rent-seeking activities result in distortions with respect to the first-best optimum, economic growth is thereby deleteriously affected. Examples include foreign currency regulations that lead to the establishment of a parallel market (and thus dual exchange rates), interest rate ceilings that lead to negative real rates of interest, preferential credit policies that target specific sectors or economic agents, restrictions on foreign trade, and the regulation of domestic prices at either the consumer or producer level.

The pursuit of exchange rate unification, currency convertibility, fiscal reform or commercial and financial liberalization must be preceded by the establishment of a policy consensus. And such a consensus may only be reached once there is common knowledge of the concessions that each group is willing to make (Alesina and Drazen, 1991). Indeed, each ethnic group will usually be the beneficiary of a specific form of economic rent, and will fail to internalize the costs that this rent imposes on the other ethnic groups (Shleifer and Vishny, 1993). Policy reform is thus slowed, if not paralyzed, by informational costs (see Schiff, 1995, 1998, for a theoretical model). This informational effect associated with ethnic fragmentation and policy reform might be labeled as the "rent keeping and reform attrition" effect.

Ethnicity and Communication

It is not difficult to see why an ethnically homogeneous population should be conducive to a private allocation of resources that moves one towards the efficient frontier, and to public goods being more efficiently provided. Similarly, a state of ethnic consensus should also lead to a higher likelihood of non-distortionary economic policies being implemented. It is also highly likely that ethnic polarization - the coexistence of two ethnic groups of roughly similar size- will lead to a sharp segmentation of markets as well as to conflicts that will negate attempts at consensus-building. Conversely, when there are a great number of ethnic groups of small size (and the index of ethnic fragmentation is therefore large compared with the polarized case), ethnically-motivated barriers to the efficient allocation of resources may be more difficult to maintain and the risks of conflict may diminish. This first argument justifies our hypothesis, enunciated in the preceding section, that the relationship between ethnic fragmentation and growth may be a U-shaped one.

Our second argument is that the benefits of an increase in ethnic fragmentation (from a starting value strictly greater than 0.5) vanish when informational costs are high since there will be little chance of reconciling heterogeneous preferences regarding the allocation of private resources or the provision of public goods, as well as more resistance to the elimination of economic rents. This would appear to be particularly likely in countries where illiteracy rates are high. In a typical manifestation of this phenomenon, the official language may be spoken and understood in written form by a relatively small proportion of the population. Low population density will exacerbate these tendencies as communication costs will be relatively high, and ethnic groups will often be more isolated geographically. Thus, in the presence of a combination of high levels of illiteracy and low levels of population density, there will be a tendency for the quadratic term in the relationship between the growth rate of per capita GDP and ethnic fragmentation to vanish.

The preceding two arguments suggest that the relationship between the growth rate of GDP and the level of ethnic fragmentation may depend upon a country's illiteracy rate as well as its population density. Our theoretical construct corresponds to the hypothesis that countries may be divided into two groups, corresponding to a "low communication costs" regime (in which the impact of ethnic diversity on the growth rate is U-shaped), and a "high communication costs" regime (in which the impact of ethnic diversity is unambiguously negative).

Moreover, if our theoretical line of reasoning is valid, it should be the case that the negative effect of ethnic fragmentation on growth in the second "high communication costs" regime is stronger the greater are communication costs, in particular, the greater is the illiteracy rate. This suggests that the appropriate specification in the "high communication costs" regime involves entering ethnic fragmentation in multiplicative form, multiplied, that is, by the illiteracy rate.

It is worth noting that this last hypothesis (were it not to be rejected by the data) furnishes an answer to a question posed by Temple (1998) in the conclusion of his paper. Having specified a quadratic relationship between ethnic fragmentation and growth, he finds himself puzzled by the low growth rate of subsaharan African countries, as their level of ethnic fragmentation is particularly high, thus leading his model to predict a higher growth rate for these countries. And this, despite his intuition, as suggested by Easterly and Levine, that the high degree of ethnic fragmentation in Africa constitutes part of the explanation for the low growth rate of these economies.

Finally, an hypothesis that constitutes an alternative to our own is provided by Collier (1998), who suggests that the impact of ethnicity on growth depends upon the nature of political rights. Ethnicity is considered to be more detrimental to growth in non-democratic societies because of the absence of institutions that allow ethnic tensions to be peacefully channelled into productive policies. Although Collier's argument is appealing, we prefer our explanation based on communication costs, because it is highly likely that ethnicity is an important determinant of the nature of political rights. Moreover, there is no reason to believe that ethnicity affects growth chiefly through indirect effects mediated by policies, as would be implied by Collier's hypothesis.

IV. Empirical Analysis

Dealing with Parameter Instability

The basic empirical relationship that we estimate corresponds to the by now standard growth regression used by most authors in the literature in which the growth rate of per capita GDP is related to (i) the initial level of per capita GDP (expressed in logarithmic terms), (ii) the level of human capital as measured by the average number of years of schooling (we use the measure constructed by Barro and Lee (1993)), (iii) a decade dummy (we confine our attention to the 1970s and 1980s). The fourth

explanatory variable that we introduce is the index of ethnic fragmentation, which we introduce in linear (column 1, Table I), as well as in quadratic form (column 2). When ethnicity enters in purely linear form, we are in a situation in which the impact of ethnicity on growth is unambiguously negative. On the other hand, when ethnicity enters in quadratic form, we are in a case in which the impact of ethnicity on growth is based on polarization concerns. The first case is that considered by Easterly and Levine (1997), whereas the second is close in spirit to the specification implemented by Temple (1998). Observations are pooled by countries over two decades as in Easterly and Levine (1997). Moreover, this formulation is particularly appropriate in the context of the estimation at hand, first because certain control variables in the growth regressions, such as the average number of years of schooling, change from one decade to the next and, second, because the variables associated with communication costs that we will be considering below, also may change from one decade to the next. Standard errors were computed using White's heteroskedasticity-consistent method.

In the linear specification, presented in column 1 of Table I, ethnic diversity is statistically significant at the usual levels of confidence. Similarly, in column 2, though ethnic diversity and ethnic diversity squared are not individually significant, they are so jointly, as indicated by the p-value of the associated c^2 statistic, which is equal to 0.010. The quadratic specification is marginally prefered to its linear counterpart on the basis of a likelihood ratio test (p-value = 0.101), though this result does not allow one to come down unambiguously in favor of either of the specifications. This ambiguity in terms of specification suggests that our hypothesis regarding a potential heterogeneity in the impact of ethnic diversity on growth is not entirely misplaced. In order to test formally for the presence of these potential differences in the impact of ethnic diversity it would appear to be reasonable to proceed on the basis of conventional Chow tests stemming from the division of the sample into two subsamples based on a number of exogenous criteria.

A first preliminary test of our hypothesis based on communication costs is given by the results of a Chow test that are presented in the lower part of the first two columns of Table I. In this Chow test, we construct a subsample of observations given by those countries corresponding to the fourth quartile of the *ratio* of the illiteracy rate to the population density. *A priori*, these should be countries in which communication costs are particularly high. For this sample split, the p-values of the tests are extremely small (0.007 and 0.039, respectively, for the linear and quadratic specifications), indicating that one can readily reject the null-hypothesis of parameter constancy across the two subsamples.

Of course, other exogenous factors might be just as relevant as a basis on which to construct subsamples which are then subjected to Chow tests. For example, the impact of ethnic diversity on growth may differ according to the level of development, proxied by GDP per capita. This effect may also differ on the basis of human capital, reflected in the average number of years of schooling in the working age population. Empirical results corresponding to these two hypotheses are also presented in Table I. A Chow test based on the median value of GDP per capita leads one to reject the null hypothesis of parameter stability (p-value = 0.09) in the case of the linear specification (column 1), and the same is true in the case of the specification that is quadratic in ethnic diversity (column 2, p-value = 0.061). This is compatible with an argument based on communication costs, since GDP per capita is highly correlated with the literacy rate. On the other hand, though schooling is highly correlated with GDP per capita, sample separation based on the median value of the average number of years of schooling does not lead, in either of the two specifications, to the rejection of the null hypothesis of parameter stability : this is in sharp contrast, of course, to our results based on communication cost arguments, proxied by the ratio of illiteracy to population density.

The impact of ethnic diversity on growth may also be linked to geographical concerns. For example, several authors, such as Easterly and Levine (1997), Temple (1998) and Collier and Gunning (1999) argue that the higher levels of ethnic diversity in Africa have contributed to the slow growth of that continent. It is troubling, in the context of such arguments which are fundamentally based on an internationally valid, and stable, relationship, to find that Chow tests constructed on the basis of the geographical region to which a given country belongs (such as Africa or Latin America) both strongly reject the null hypothesis of parameter stability. Results corresponding to Chow tests in which we consider the subsamples constituted by African and Latin American countries are also presented in the first two columns of Table I. In all cases, the null hypothesis of parameter stability across subsamples is strongly rejected by the data.

A second test of our ethnicity and communication cost hypothesis is given by three specifications where either the illiteracy rate or the logarithm of the population density (or both variables) appear in multiplicative form. This allows the marginal impact of ethnic diversity on the growth rate of per capita GDP to be a function of our proxies for the level of communication costs. If we focus our attention on column 5 in which the impact of ethnolinguistic fragmentation on growth is allowed to vary as a function of both the illiteracy rate and the logarithm of population density, it is obvious, given the p-value on the joint significance test (0.042), that it would be erroneous to assume that the impact of ethnic

fragmentation on growth is independent of communication costs. The same applies in the context of the quadratic specification (columns 6 to 8).

While the results of the Chow tests as well as the multiplicative specifications do suggest that the relationship between the growth rate of per capita GDP and ethnic fragmentation is a function of our communication variables, these two procedures did not allow us to argue convincingly in favor of either the linear or the quadratic specification. Another approach is therefore needed in order to directly test our hypothesis. This is because our hypothesis does not involve choosing between the linear and the quadratic specification. Rather, the point is to identify, on the basis of our proxies for communication costs, those countries for which the relationship is linear, and those countries for which the relationship is quadratic. Essentially, the point is not that one of the two specifications is wrong. Rather, our hypothesis is that both specifications are right, depending on the level of communication costs.

A Two Regime Specification

In order to condition the relationship between ethnic diversity and the growth rate of GDP per capita in a manner that corresponds to the theoretical arguments enunciated above, we turn to a switching regression specification in which regime 1 corresponds to the "low communication costs" scenario and regime 2 corresponds to the "high communication costs" scenario. Whether a country belongs to regime 1 or regime 2 will depend simultaneously upon its illiteracy rate and its population density.

Let x_i ($i = 1,...,N$, indexes observations) denote the $N \times 4$ matrix of control variables that is common to both regimes (a constant term, the initial level of GDP per capita, a decade dummy, and the Barro-Lee measure of human capital). Let $x_{1i} = [x_i \;\; ELF60_i \;\; ELF60_i^2]$ denote the $N \times 6$ matrix of explanatory variables that correspond to regime 1 and $x_{2i} = [x_i \;\; ELF60_i \times ILLITERACY_i]$ denote the $N \times 5$ matrix of explanatory variables that corresponds to regime 2; the dependent variable (the growth rate of per capita GDP) will be denoted by y_i with y_{1i} denoting the growth rate under regime 1 and y_{2i} denoting the growth rate under regime 2. The econometric specification is then given by the following system of equations:

$$\text{Regime } 1: y_{1i} = b_1' x_{1i} + u_{1i}$$
$$\text{Regime } 2: y_{2i} = b_2' x_{2i} + u_{2i}$$

where the choice between regimes is given by the following sorting condition

$$y_i = \begin{cases} y_{1i} \ \ if \ \ g'z_i + v_i < 0 \\ y_{2i} \ \ if \ \ g'z_i + v_i \geq 0 \end{cases}$$

with $v_i \sim N(0,1)$, and where z_i is an $N \times 3$ matrix constituted by a constant term, the illiteracy rate, and the logarithm of population density. The distributional assumptions on the disturbance terms in the two regimes are given by $(u_{1i}, u_{2i}) \sim N(0,0,\Sigma)$. That is, the disturbance terms in the two equations are distributed according to the bivariate normal density with zero means and covariance matrix given by

$$\Sigma = \begin{bmatrix} s_1^2 & s_{12} \\ s_{12} & s_2^2 \end{bmatrix}.$$

It is well known (e.g., Maddala (1983), Quandt (1988)) in the context of this type of model that the off-diagonal term s_{12} is not identifiable. Note that, for identification purposes (Maddala and Nelson (1975), p. 424), we must (i) normalize the standard deviation of the selection equation such that it is equal to one (that is why v_i is distributed $N(0,1)$ and not $N(m_v, s_v^2)$) and (ii) normalize the coefficient on the constant term in the selection equation to one (i.e., the parameters in the selection equation are only identified up to a multiplicative constant).

The selection equation which determines whether a country belongs to regime 1 or regime 2 is given by a (latent) regime indicator function defined as follows :

$$I_i(z_i) = \begin{cases} 1 \ if \ \ g'z_i + v_i < 0 \\ 0 \ \ if \ \ g'z_i + v_i \geq 0 \end{cases}$$

We can therefore write our left-hand-side variable from the growth equations in the following form:

$$y_i = I_i(z_i) b_1' x_{1i} + (1 - I_i(z_i)) b_2' x_{2i} + I_i(z_i) u_{1i} + (1 - I_i(z_i)) u_{2i},$$

where we approximate $I_i(z_i)$ in continuous form by the probit function :

$$\hat{I}_i(z_i) = \int_{-\infty}^{g z_i} \left(\frac{\exp\{-v^2/2\}}{\sqrt{2p}} \right) dv .$$

One can then easily construct the corresponding likelihood function and maximize it with respect to b_1, b_2, s_1, s_2, g which, owing to the above normalizations, are all identifiable. Note that this procedure does not arbitrarily assign an observation to a given regime : this process is carried out optimally through the maximization of the likelihood function, thus allowing the data (conditioned by the variables included in the selection equation) to sort themselves freely into the two regimes.

The results are presented in Table II. In the first column, the difference between the two regimes is that ethnic diversity enters in quadratic form in regime 1 and in linear form in regime 2. In column (2), ethnic diversity enters in multiplicative form, as our formal hypothesis would have it, in regime 2. If we begin by considering the selection equation, it is worth pointing out that the coefficients on the illiteracy rate and on population density have the signs predicted by our theory (a positive sign indicates a higher probability of the observation falling under regime 2). Moreover, in column (2) ethnic diversity has the appropriate U-shape under regime 1, and both coefficients are statistically significant at the usual confidence levels, while ethnic diversity multiplied by the illiteracy rate in regime 2 is negative and statistically significant.

These results offer strong support for our main theoretical hypothesis that the impact of ethnic diversity on the growth rate of per capita GDP is conditioned by communication costs. Remarkably, for this type of switching regression, sample separation into the two regimes is crisp (with highly significant coefficients on our proxies for communication costs in the selection equation), and despite the difference between the two regimes being minimal (from the econometric point of view), the coefficients on ethnic fragmentation and ethnic fragmentation squared in regime 1, and on ethnic fragmentation times the illiteracy rate in regime 2 are estimated rather precisely.

Figure 1 illustrates the results presented in column (2) of Table II. The U-shaped curve represents the predicted impact of ethnic fragmentation on the growth rate of per capita GDP for those observations belonging to regime 1, once the growth rate has been purged of the effects of the usual control variables. The straight lines represent the predicted value of the growth rate of GDP per capita for observations belonging to regime 2, for different values of the illiteracy rate. The middle straight line corresponds to the median value of the illiteracy rate of countries that belong to regime 2. The uppermost and lowermost straight lines correspond to a illiteracy rates equal to the cutoff value between

the first and second quartiles, and the third and fourth quartiles, respectively. Note that the minimum value of the predicted growth rate of per capita GDP for countries that belong to regime 1 is attained at ELF60 near 0.4 —not far from our theoretically motivated value of 0.5.

From the empirical results in Table II we can construct the predicted probability of a given observation (country) belonging to regime 1 or regime 2. Since the true indicator function is approximated by the probit function, these probabilities will not appear in discrete (i.e., 0 or 1) form, that is, they will often be strictly comprised between zero and one. Table III presents the probability of various groupings of countries belonging to regime 2. As expected, African, Latin American and the poorest countries in the sample have a significantly higher probability of belonging to the linear (multiplicative) regime.

A potential problem with any relatively complex econometric procedure such as the one that we have implemented is that, despite its theoretical appeal, it might not fit the data particularly well. This is often a problem in the context of cross-sectional growth regressions, in which the presence of outliers is notoriously common. In order to check for the presence of outliers, Figure 2 plots the observed growth rate of GDP per capita (purged of the effects of the usual control variables) on ethnic diversity, for the regime in which ethnic diversity enters in quadratic form. There is only one obvious outlier, constituted by Belgium in the 1970s. Re-estimation of all of our equations while deleting this observation did not change the results. In particular, in the switching regression specification, neither the selection equation, nor the growth equations are in any way modified, by the exclusion of this observation. Figure 3 plots the same Figure for the regime in which ethnic diversity enters in multiplicative form. Here, in contrast to the quadratic regime, there are no obvious outliers.

A second concern that arises in the context of a switching regression specification is that the separation of observations into two regimes might not be particularly clear, in the sense that many observations may lie extremely close to frontier that separates the two regimes. In Figure 4, we plot the frontier between the two regimes, given by the selection equation in the switching regression procedure, as well as the observations as they are classified according to regime. As is evident from the Figure, sample separation is extremely crisp, and it is graphically evident that both illiteracy and population density are significant determinants of whether a country falls in the linear (multiplicative) or quadratic regime. Moreover, most observations corresponding to subsaharan Africa lie well to the southeast, indicating, as was revealed by the averages presented in Table III, that communication costs provide a cogent explanation for the highly deleterious impact of ethnic diversity in these countries. On the other

hand, it is obvious that for the case of Mauritius, that lies tantalizingly close to the frontier, that a small effort in reducing illiteracy would result in the impact of ethnic diversity becoming positive as it would pass into the quadratic regime. On the basis of sample separation and the absence of influential outliers, therefore, we conclude that our main results based on the switching regression specification are remarkably robust.

The Dominant Transmission Mechanism

In order to study whether the impact of ethnic diversity on growth operates through the direct or indirect (i.e., policy-mediated) mechanisms posited above, we first regressed several standard macroeconomic policy variables commonly used in the empirical growth literature, on ethnic diversity and we did so separately for those observations corresponding to each of our two regimes, by including, as an additional explanatory variable, the predicted probability of an observation belonging to a given regime, obtained from our switching regression procedure.

Second, in order to avoid problems stemming from the manifest underspecification of these simple policy regressions, we reconsidered our growth regressions by including, as additional explanatory variables, the aforementioned policy variables : the distinction between indirect and direct transmission of the impact of ethnic diversity depends, of course, on whether the coefficient associated with ethnic diversity falls significantly when the policy variables are introduced into the specification, when one compares this coefficient with that associated with ethnic diversity in a similar regression in which the policy variables are excluded.

Our choice of macroeconomic policy variables, the black market premium, the fiscal surplus and financial depth, was in large measure determined by previous work in this area (see Easterly and Levine, 1997, as well as Sachs and Warner, 1996).[3] The black market premium is a good indicator of those distortions induced by foreign exchange restrictions and the misallignment of exchange rates. A fiscal deficit can be interpreted as a symptom of an inability to implement adequate policies and is often associated with significant distortions stemming from tariff and taxation policies. Low financial depth, measured by the ratio of liquid assets to GDP, is often taken to be the result of financial repression, but can also reflect individual saving behavior independent of macroeconomic policies (for instance, a

[3] The sample used in these estimations is necessarily smaller than that used in our basic switching regression specification in that there are many observations for which the policy variables in question are missing.

reluctance to make deposits in banks controlled by other ethnic groups and a preference for informal and ethno-specific credit associations).

First, consider the results based on the subsample of those countries classified by our switching growth regression procedure (column (2) of Table II) as belonging to regime 2. In essence, we thus carried out a Heckman procedure where we control for selection bias by introducing, as an additional explanatory variable, the predicted probability of belonging to regime 2 computed in column (2) of Table II. The empirical results corresponding to this procedure are reported in Table IV.[4] It is apparent from the results that it is financial depth that is significantly and negatively affected by ethnic diversity for countries belonging to regime 2 (note that the coefficient on the predicted probability of the observation belonging to regime 2 is also statistically significant at the usual levels of confidence), while the impact of ethnic diversity on the fiscal surplus and on the premium on the black market exchange rate premium is statistically insignificant. If one interprets financial depth as a "structural", rather than as a "policy" variable, as argued above, then it is more indicative of a direct rather than an indirect effect of ethnic diversity on the growth rate. Roughly the same arguments apply to those countries classified as belonging to regime 1.

We now turn to those results stemming from the growth regressions presented in columns 3 and 4 of Table II. Here, the evidence is particularly unambiguous : there is no statistically significant (at the usual levels of confidence) fall in the coefficient associated with ethnic diversity when the three policy variables are introduced, indicating that direct transmission mechanisms dominate[5]. Moreover, as has been found previously (e.g. Easterly and Levine, 1997), the policy variables are all highly significant at the usual levels of confidence.

It would appear, therefore, that the differential impact of ethnic diversity on the growth rate of GDP per capita in the two regimes does not obtain through a differential impact of ethnic diversity on macroeconomic policy choices that, in turn, affect the incentives facing economic agents. Rather, there is a direct effect of ethnic diversity on the growth rate of GDP that differs according to whether a country is in the "low communication costs" versus the "high communication costs" regime. It should be

[4] As we were seeking to maximize sample size, the relevant sample here includes a number of observations which were not included in the sample in column (2) of Table II, but for which we could nevertheless (i) construct the estimated probability of being in regime 2 and (ii) perform the regression of the policy variables on ethnic diversity while controlling for selection bias. The results do not differ appreciably if we confine our attention to those observations corresponding to regime 2 in the switching regression results reported in column (2) of Table II and for which the policy variables are also available.

[5] Indeed, in the quadratic specification, it is only when the policy variables are included that the coefficients associated with ELF60 and ELF60 squared become statistically significant.

noted that these results are in contrast with Easterly and Levine (1997) and Temple (1998) who both assume that ethnic diversity affects growth through its impact on policy variables. Our paper generalizes their results and combines them, in the sense that Easterly and Levine introduce ethnic fragmentation in linear form, whereas Temple introduces it in quadratic form. Neither Easterly and Levine nor Temple, however, allow for a differential impact of ethnic diversity based on a third group of variables.

V. Concluding Remarks

The contribution of this paper about the impact of ethnic diversity on growth lies in (i) our having gone beyond the usual linear specification adopted by most authors, and (ii) our having shown that this impact differs for different categories of countries. In a context in which ethnic *polarization* rather than diversity is harmful for growth, the relationship between growth and ethnic diversity may be non-linear. Our principal hypothesis was that the impact of ethnic diversity depends on the level of communication costs within a country. This naturally leads one to a two-regime specification in which proxies for communication costs allow one to distinguish between two subsamples of countries.

We investigated these hypotheses in three successive steps. First, using simple Chow tests, we considered whether the regression coefficients in the basic specifications of the determinants of growth were stable across subsamples constructed on the basis of differing levels of communication costs, GDP per capita, human capital, or geographical concerns.

Second, we considered whether the marginal impact of ethnic diversity on growth was a function of communication costs by using a simple multiplicative specification. In both cases, we proxied these communication costs by the illiteracy rate and the population density : our results indicated that one cannot reject the null hypothesis that the cost of communication is a significant determinant of the marginal impact of ethnic diversity on growth.

Third, we considered a switching regression model with exogenous switching, in which regime 1 corresponds to "low communication costs countries" while regime 2 corresponds to "high communication costs countries". In regime 1, ethnic diversity enters in quadratic form, and while the expected sign on ethnic diversity is negative, the expected sign on ethnic diversity, squared, is positive, implying a U-shaped relationship between the growth rate of GDP per capita and ethnic diversity, conditional on the usual control variables. In regime 2, on the other hand, ethnic diversity enters in

multiplicative form (multiplied by the illiteracy rate), and the expected sign of the coefficient is negative. Our selection equation, for its part, is a function of our two proxies for communication costs.

Finally, we considered whether the impact of ethnic diversity on growth was direct or mediated through policy variables. In order to do so, we investigated the differential impact of ethnic diversity on three policy variables commonly used in the empirical growth literature. We did so, first, by carrying out what essentially boils down to a Heckman procedure : for a subsample of observations classified by our switching growth regression as belonging to a given regime, we regressed each policy variable on ethnic diversity while including the predicted probability (computed from the selection equation of the switching growth regression) of the observation belonging to that regime. Second, we re-estimated our basic growth regressions using the same Heckman procedure as for the policy regressions.

Our results showed (i) that two of the three commonly used policy variables were statistically unrelated to ethnic diversity when one controls for sample selection bias, and (ii) the coefficient associated with ethnic diversity does not fall significantly in a growth regression when the policy variables are included in the specification. Both of these results suggest that ethnic diversity does not affect growth through its impact on policy decisions. Rather, it is the direct transmission mechanism that dominates.

The policy implications of our results, in contrast to other recent papers (e.g. Easterly and Levine, 1997), are not so depressing. When the impact of ethnic diversity on growth is unambiguously negative, a high of degree of ethnic diversity would appear to be a question of fate, in the sense that it inexorably lowers the growth rate of GDP per capita. In our results, on the other hand, ethnic diversity, for countries that belong to regime 2, is a severe handicap that can, however, be overcome. Indeed, through literacy programs and improvements in infrastructure possibly supported by external assistance, a country should be capable, first (while remaining within regime 2), of dampening the deleterious effects of ethnic fragmentation (reducing the absolute value of the slope of the straight line in Figure 1) and, later, of switching over to what we have deemed regime 1, the "low communication costs regime". In the context of Figure 4, this means moving from the southeast of the frontier given by the selection equation to the northwest of the frontier. Having operated this switch, ethnic diversity, rather than constituting a fetter on growth, can become an asset.

Ethnicity, we have shown, is not important because of its effect through macroeconomic policies. Therefore, even with a high degree of ethnic diversity, there is nothing that condemns a country

to pursuing poor policies. Of course, there may be other aspects of policy, that are not captured by the three proxies commonly used in the empirical growth literature (black market premium, fiscal surplus and financial depth), and that are affected by ethnic diversity.

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TABLE I. BASELINE SPECIFICATION AND TESTS OF ROBUSTNESS (DEPENDENT VARIABLE : GROWTH RATE OF GDP PER CAPITA; 157 OBSERVATIONS)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant	0.007	0.015	0.025	0.005	0.019	0.025	0.012	0.019
	(0.31)	(0.62)	(1.02)	(0.23)	(0.75)	(1.04)	(0.47)	(0.77)
Dummy for the 70s	0.019	0.019	0.018	0.019	0.019	0.018	0.019	0.019
	(5.33)	(5.32)	(5.25)	(5.52)	(5.43)	(5.22)	(5.49)	(5.40)
Log of initial income	-0.0004	-0.002	-0.001	0.0001	-0.0009	-0.002	-0.001	-0.001
	(-0.11)	(-0.56)	(-0.47)	(0.04)	(-0.24)	(-0.66)	(-0.32)	(-0.40)
Log of schooling	0.007	-0.008	0.002	0.005	0.001	0.003	0.006	0.003
	(1.31)	(-1.45)	(0.33)	(0.90)	(0.24)	(0.57)	(1.04)	(0.46)
Ethnic fragmentation	-0.018	0.020	-0.001	-0.036	-0.020	0.018	-0.002	-0.0009
	(-2.46)	(0.74)	(-0.09)	(-2.67)	(-1.15)	(0.65)	(-0.05)	(-0.02)
Ethnic fragmentation, squared		-0.047				-0.029	-0.040	-0.027
		(-1.50)				(-0.75)	(-1.13)	(-0.67)
Joint significance of ethnic fragmentation and ethnic fragmentation, squared (p-value)		$\chi^2(2)=9.07$ (0.010)						
Likelihood ratio test of linear versus quadratic specification (p-value)		$\chi^2(1)=2.67$ (0.101)						
Multiplicative variables								
Ethnic fragmentation × illiteracy rate			-0.034		-0.026	-0.026		-0.018
			(-2.17)		(-1.63)	(-1.27)		(-0.92)
Ethnic fragmentation × log of population density				0.005	0.004		0.004	0.004
				(1.45)	(1.19)		(1.26)	(1.16)
Test on joint significance of multiplicative terms (p-value)					$\chi^2(2)=6.331$ (0.042)			$\chi^2(2)=4.399$ (0.110)
Chow tests : criteria for construction of subsamples								
Fourth quartile of the ratio of illiteracy on population density (p-value)	$\chi^2(5)=15.66$ (0.007)	$\chi^2(6)=13.19$ (0.039)						
Median level of GDP per capita (p-value)	$\chi^2(5)=9.50$ (0.090)	$\chi^2(6)=12.01$ (0.061)						
Median level of schooling (p-value)	$\chi^2(5)=1.78$ (0.877)	$\chi^2(6)=5.42$ (0.490)						
Subsaharan Africa (p-value)	$\chi^2(5)=14.40$ (0.013)	$\chi^2(6)=19.64$ (0.003)						
Latin America (p-value)	$\chi^2(5)=29.34$ (0.000)	$\chi^2(6)=31.38$ (0.000)						
R-squared	0.224	0.237	0.241	0.246	0.225	0.245	0.255	0.224

Note: White heteroskedasticity-consistent t-ratios in parentheses, unless otherwise noted. Datasource : growth rate of GDP per capita, log of initial income, log of schooling, and ethnic fragmentation, Easterly and Levine (1997); Illiteracy rate and population density : World Bank data.

TABLE II. SWITCHING REGRESSION WITH EXOGENOUS SWITCHING AND UNKNOWN SAMPLE SEPARATION AND HECKMAN PROCEDURE (T-STATISTICS IN PARENTHESES)

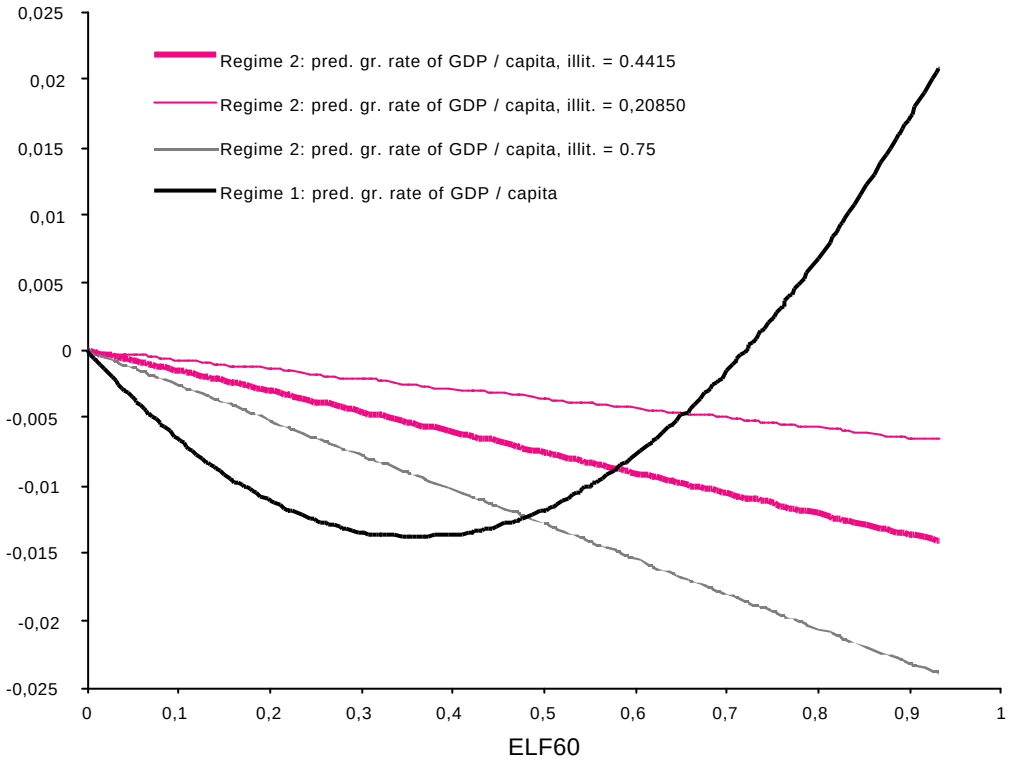
	Switching regression		Heckman procedure	
	1	2	3	4
Selection equation				
illiteracy rate	24.81	27.21		
	(2.22)	(2.12)		
population density	-0.735	-0.778		
	(-3.10)	(-3.05)		
Regime 1				
constant	0.200	0.205	0.195	0.428
	(7.08)	(7.32)	(2.20)	(11.48)
elf60	-0.077	-0.077	-0.048	-0.073
	(-2.89)	(-2.84)	(-1.05)	(-2.25)
elf60, squared	0.105	0.107	0.039	0.127
	(2.31)	(2.29)	(0.38)	(2.05)
dummy for 1970s	0.003	0.003	0.006	-0.004
	(1.03)	(0.99)	(1.25)	(-1.33)
log of schooling	0.005	0.005	0.010	-0.011
	(0.68)	(0.63)	(0.85)	(-1.01)
log GDP/capita	-0.019	-0.020	-0.021	-0.036
	(-5.55)	(-5.54)	(-1.99)	(-8.22)
σ_1	0.006	0.006		
	(6.13)	(6.58)		
Predicted probability of being in regime 1			0.007	-0.040
			(0.46)	(-2.99)
Financial depth				0.010
				(2.54)
Fiscal surplus / GDP				0.187
				(3.83)
Black market premium				-0.162
				(-4.45)
Number of observations : Heckman procedure			35	26
Regime 2				
constant	-0.001	0.020	0.009	0.102
	(-0.02)	(0.53)	(0.20)	(1.93)
elf60	-0.016			
	(-1.54)			
elf60 × illiteracy rate		-0.034	-0.033	-0.028
		(-2.18)	(-2.95)	(-2.26)
dummy for 1970s	0.022	0.022	0.021	0.018
	(4.66)	(4.54)	(4.97)	(4.33)
log of schooling	0.004	-0.001	0.0002	0.0017
	(0.58)	(-0.16)	(0.03)	(0.28)
log GDP/capita	0.0006	-0.0009	-0.000	-0.011
	(0.12)	(-0.18)	(-0.009)	(-2.48)
σ_2	0.024	0.024		
	(17.50)	(18.04)		
Predicted probability of being in regime 2			0.003	-0.005
			(0.12)	(-0.24)
Financial depth				0.058
				(5.44)
Fiscal surplus / GDP				0.160
				(2.50)
Black market premium				-0.025
				(-3.17)

average prob. of regime 2	0.770	0.771		
log of likelihood function	399.33	401.29		
number of observations : switching regression	157	157		
Number of observations : Heckman procedure			122	103

FIGURE 1

SWITCHING REGRESSION WITH UNOBSERVABLE SAMPLE SEPARATION
LINEAR-MULTIPLICATIVE (WEAKLY INTEGRATED) AND QUADRATIC (HIGHLY INTEGRATED) REGIMES

(Growth rate of GDP per capita conditional on constant, decade dummy, linear convergence effect and schooling on vertical axis)



Note : U-shaped curve corresponds to predicted value of growth rate as a function of ELF60 in highly integrated regime (regime 1). Middle straight line corresponds to predicted value of growth rate in weakly integrated regime (regime 2) estimated at the median value of illiteracy for observations belonging to regime 2. Upper and lower straights lines represent predicted value of growth rate estimated for illiteracy rate equal to the limit value separating the first from the second quartile, and the third from the fourth quartile, respectively.

FIGURE 2

SWITCHING REGRESSION WITH UNOBSERVABLE SAMPLE SEPARATION

QUADRATIC (HIGHLY INTEGRATED) REGIME

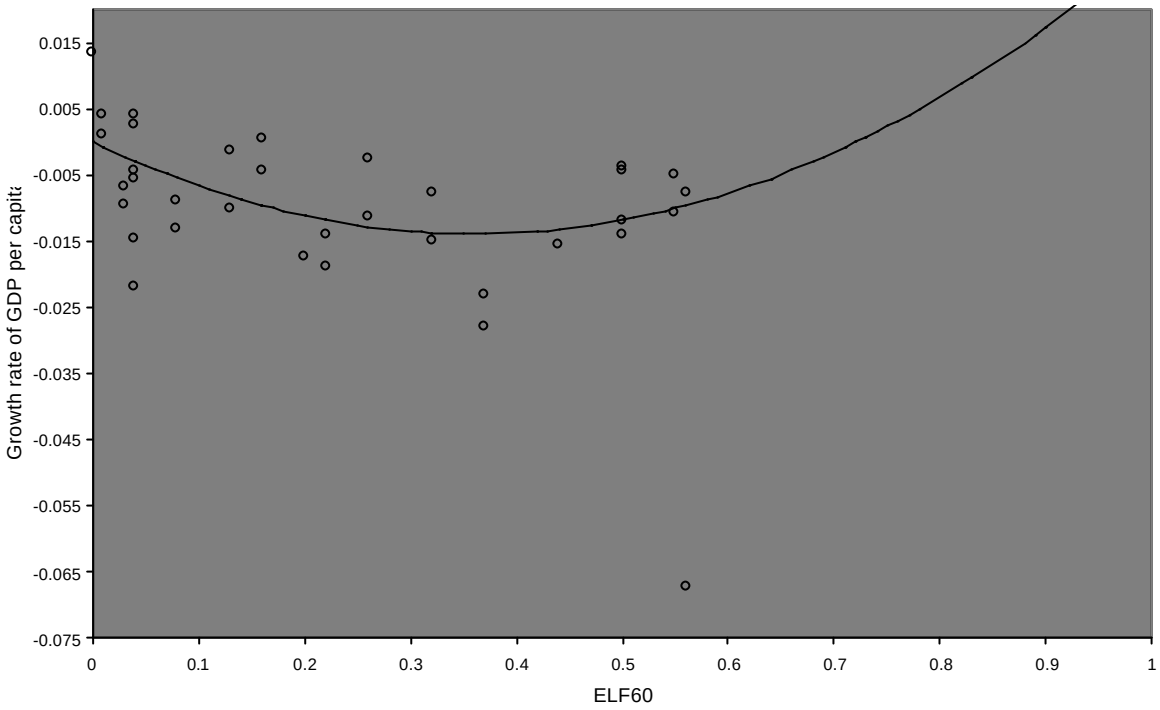


FIGURE 3

SWITCHING REGRESSION WITH UNOBSERVABLE SAMPLE SEPARATION

MULTIPLICATIVE (WEAKLY INTEGRATED) REGIME

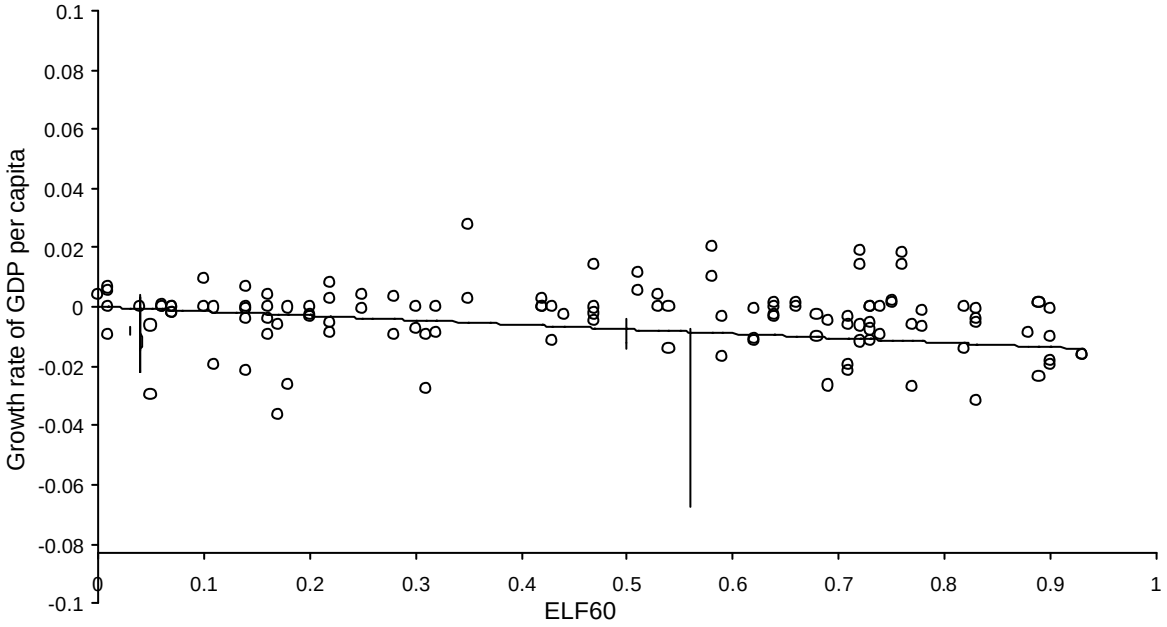


FIGURE 4

SWITCHING REGRESSION WITH UNOBSERVABLE SAMPLE SEPARATION

THE SELECTION EQUATION AND SAMPLE SEPARATION

AS DETERMINED BY ILLITERACY AND LOG OF POPULATION DENSITY

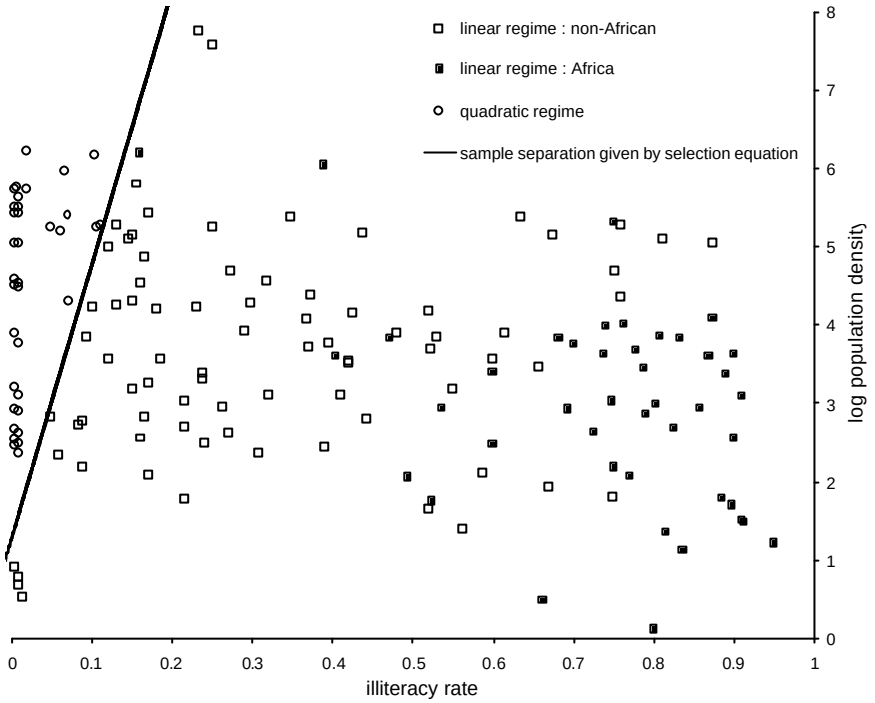


TABLE III

PREDICTED PROBABILITIES OF BELONGING TO REGIME 2, BY GROUPING

Subsample	No. Obs.	Mean estimated probability of being in regime 2	Standard deviation
Full sample	157	0.771	0.373
African	43	0.993	0.045
Non-African	114	0.687	0.407
Latin American	42	0.880	0.255
1st quartile of GDP per capita	39	1.000	0.000
4th quartile of GDP per capita	39	0.227	0.299

Note : computed from the estimated value of the probability of belonging to regime 2 based on the switching regression presented in column (2) of Table II.

TABLE IV

CORRELATION BETWEEN POLICY VARIABLES AND ETHNIC DIVERSITY

UNDER BOTH REGIMES

	Regime 1						Regime 2		
Dependent variable	Financial depth	Black market premium	Fiscal surplus / GDP	Financial depth	Black market premium	Fiscal surplus / GDP	Financial depth	Black market premium	Fiscal surplus / GDP
Constant	-0.133	0.142	-0.025	-0.039	0.190	-0.010	0.920	-0.347	-0.092
	(-0.39)	(1.63)	(-0.27)	(-0.11)	(2.41)	(-0.10)	(4.82)	(-1.62)	(-1.45)
Ethnic fragmentation	0.067	0.117	0.005	-0.749	-0.291	-0.082	-0.158	0.058	-0.008
	(0.25)	(1.32)	(0.14)	(-0.77)	(-1.18)	(-0.51)	(-2.30)	(0.45)	(-0.57)
Ethnic fragmentation, squared				1.468	0.736	0.153			
				(0.95)	(1.30)	(0.51)			
Predicted probability of	0.829	-0.160	-0.014	0.785	-0.182	-0.024	-0.536	0.633	0.049
being in relevant regime	(2.25)	(-1.71)	(-0.14)	(2.09)	(-2.25)	(-0.24)	(-2.61)	(2.53)	(0.76)
R-squared	0.128	0.209	0.004	0.147	0.284	0.016	0.126	0.023	0.011
No. of observations	35	35	26	35	35	26	119	122	105

Note : White heteroskedasticity-consistent t-ratios in parentheses. Predicted probability of being in a given regime computed from column (2) of Table II.