Ethnic Fractionalization, Governance, and Loan Defaults in Africa*

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Abstract

We present a theoretical model of an imperfectly competitive loans market that is suitable for emerging economies in Africa. The model allows for variation in both the level of contract enforcement (the quality of governance) and the degree of market segmentation (the level of ethnic fractionalization). The model predicts a specific form of non-linearity in the effects of these variables on loan default. Empirical analysis using African panel data for 110 individual banks in 28 countries over 2000-2008 provides strong evidence for these predictions. Our results have important implications for the conditions under which policy reform will enhance financial development.

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I. Introduction

In terms of financial development, Africa still lags behind other parts of the world. African banks are deterred from lending in domestic markets by a lack of creditworthy borrowers, and loan volumes are highly sensitive to default rates (Adrianova *et al*., 2015). As a result, many African banks are excessively liquid and channel an unusually large proportion of domestic savings abroad, although there is substantial variation in banks' default risk and asset structure, both within and between countries (Honohan and Beck, 2007). At the same time, firm and household surveys reveal endemic credit constraints. For this reason, understanding the determinants of the rate of loan default is crucial in overcoming obstacles to financial development in Africa. Our paper makes a first step in this direction by providing both theory and evidence that shed new light on the factors behind the high rate of loan default in many parts of Africa.

The focus of attention in both the theoretical and empirical parts of the paper is on two key characteristics of the African banking sector. Firstly, there is a great deal of variability across Africa in terms of both the level of corruption and the quality of contract enforcement. This variability is revealed in indices of the quality of governance produced by organisations such as the World Bank, Transparency International, and the Bureau van Dijk. Daumont *et al*. (2004) argue that weak contract enforcement in Africa is due to a number of factors, including excessively time-consuming and unwieldy legal procedures, high litigation costs, a lack of appropriately qualified judges, and inadequacies in the cadastral system that inhibit the identification of collateral property. The large variation in the magnitude of these problems across Africa suggests that they may help explain the observed variation in the incidence of loan default. Secondly, many African countries are characterized by a high level of ethnic fractionalization (Easterly and Levine, 1997). A lack of trust between different ethnic groups is likely to generate high inter-ethnic transactions costs, which will lead to a high level of market segmentation (Aker *et al*., 2010; Robinson, 2013). Existing studies of ethnic market segmentation have not focused explicitly on financial markets, but there is no reason to suppose that financial markets are any less susceptible to this problem than others. Even in countries with a large banking sector, ethnic fractionalization is likely to create monopolistic competition, because banks are differentiated by the ethnicity of their staff. African banks are therefore likely to face unusually inelastic demand curves.

Our paper builds on Andrianova *et al*. (2015), who show that loan defaults are a major factor inhibiting African bank lending when institutional quality is low, but do not give any evidence on the causes of high loan default. Our paper presents an empirical analysis of the causes of high default rates which is informed by a theoretical model of an imperfectly competitive banking sector. Our model is a refinement of the model in Andrianova *et al*., capturing the nature of market segmentation in a more realistic way.[1]

[1] In Andrianova *et al*. (2015), bank differentiation was captured using Salop's 'circular city' framework. In the model here, differentiation is captured using the 'linear city' framework of Hotelling (1929). Using a 'linear city' framework, the level of differentiation between two banks is captured by the distance between them in a single dimension, and moving one bank further along this line unambiguously increases the level of differentiation. We believe that this second feature, which is not present in 'circular city' models, is a more realistic characterization of differentiation arising from ethnic fractionalization. The key non-linearities predicted by the 'circular city' model are also predicted by the 'linear city' model, but the finding that the model's predictions are robust with respect to differences in the topology of bank differentiation is a result which is new to this paper.

One feature of this type of model of imperfectly competitive banking which is not spelled out in Andrianova *et al*. (2015) is that it entails some specific predictions for the way in which the quality of contract enforcement and the degree of market segmentation interact in generating a certain level of loan default. The theory implies that marginal improvements in enforcement quality will reduce loan default rates only when the contract enforcement problem is initially neither much more severe nor much less severe than the market segmentation problem. This can help explain why in some circumstances improvements in enforcement quality have a large effect on loan default rates, but in other circumstances there may be little or no effect.

In this paper we draw out the predictions of the theoretical model regarding the interaction between the contract enforcement and market segmentation problems, and then present an empirical model of loan default rates in a panel of African banks which focuses explicitly on the interaction effects. To our knowledge, this is the first paper to derive and test these predictions.[2] In the empirical model, market segmentation is interpreted in terms of ethnic fractionalization and contract enforcement is interpreted in terms of the quality of governance as measured by the World Bank's World Governance Indicators. We find strong evidence to support the predictions of the theoretical model, which has important implications for financial development policy.

II. Theory

[2] The empirical section of Andrianova *et al*. (2015), which presents an analysis of the factors driving banks' loan-to-asset ratios (but not the factors driving default rates), does not allow for variation in the level of market segmentation associated with ethnic fractionalization.

Our starting point is a Hotelling (1929) 'linear city' model that embodies a degree of product differentiation between banks whose financial services are imperfectly substitutable.[3] The model is designed to highlight the most salient characteristics of African banking. We use the model to characterize the different equilibria that might arise in the market for loans to firms operating in a certain sector of the economy where the rate of return to investment is equal to R. Entry into the sector is restricted, so the number of firms is invariant to conditions in the loans market.[4]

There are three different types of risk-neutral firm, each of which seeks a loan of one dollar in order to undertake their investment: 'honest' borrowers (in proportion α), 'dishonest' borrowers (in proportion β), and 'opportunistic' borrowers (in proportion γ, with $\alpha + \beta + \gamma = 1$). The honest and opportunistic borrowers all have a rate of return equal to R. The honest borrowers always repay their loan but the opportunistic borrowers can choose whether to repay or default on the loan. The dishonest borrowers have a rate of return equal to zero, and this type of borrower will always default on a loan. The borrower's type is private information, but the proportions α, β and γ are public information.

Each type of borrower is uniformly distributed along a unit interval with a distribution density equal to one. Each borrower can apply for a loan from at most one bank. There are two risk-neutral banks, which are located at opposite ends of the interval. The two banks compete for loan contracts, with bank i ($i \in \{A, B\}$) setting its loan interest rate r_i to maximise its expected payoff. Applying for a loan is

[3] Some of the features of our model are shared with other theoretical models of banking with product differentiation (for example Villas-Boas and Schmidt-Moh, 1999; Hauswald and Marquez, 2006). However, these models do not allow for the variation in the quality of contract enforcement that is central to our model.

[4] See Venables (2010) for a discussion of the entry deterrence endemic in African markets.

costly to a borrower because of a transaction cost of t dollars per unit of distance between the borrower and the bank. One interpretation of the distance between the banks is that it represents an ethnic difference. For example, each of the two banks could be associated with a different tribe, with the customers coming from a variety of tribes that are culturally closer either to one bank's tribe or to the other's. (Appendix 1 discusses evidence that at least in some parts of Africa, certain banks are more strongly associated with one tribe than with another, and that there is inter-bank heterogeneity in the strength of the association with a particular tribe.) In this interpretation, t is a measure of the cost that accompanies interactions with other tribes. In general, we might expect t to be larger in countries that are more ethnically diverse and in which the unit interval in the model represents a greater cultural divide.[5] In this way, t parameterizes the magnitude of the market segmentation problem discussed in the introduction.

Each bank has sufficient funds to approve all loan applications (which is consistent with the findings of Honohan and Beck, 2007), and has the ability to screen customers. If the borrower is not honest, then with probability σ the screening technology reveals this fact (but does not reveal whether the borrower is dishonest

[5] Suppose, for example, that there is a relatively high level of ethnic fractionalization in a town. Holding population constant, this implies that the average ethnic group size is relatively small. If each bank is connected to a specific ethnic group, and locates in the town only if the size of its group is above a certain threshold level, then a low average group size makes it more likely that there will be ethnic groups which are too small for 'their' banks to operate in the town. These groups will have to deal with banks other than their own, and if this is associated with a higher transaction cost, then a higher level of fractionalization will be associated with a higher cost. Appendix 2 presents a numerical example of this effect.

or opportunistic).[6] With probability $1 - \sigma$ the screening fails to reveal any information. We assume that a bank chooses whether to screen or not to screen, and then whether to refuse or not to refuse applications from borrowers with a negative screening signal. Both banks have access to a safe asset with a return equal to r_0 ($0 < r_0 < R$).

Loan contract enforcement is imperfect. When a loan has funded a project with a return of R, default on the loan is penalized with probability λ; the penalty is equal to $1 + R$ dollars, of which the bank receives $1 + r_i$ dollars.[7] In other words, if the bank is compensated then it receives the amount stipulated in the loan contract. With probability $1 - \lambda$ no contract enforcement is possible and there is no penalty. When the loan has funded a project with a zero return then no enforcement is possible. The return on the investment is observable ex post and is non-falsifiable. The timing of events is as follows:

(1) Bank i sets its lending rate r_i.

(2) Each borrower chooses a bank to apply for a loan of one dollar.

(3) Facing a demand for loans equal to D_i, bank i chooses whether to screen all of its loan applications or not.

(4) Each bank chooses which applications to approve and which to decline.

[6] One interpretation of this screening technology is that successful screening reveals that the borrower has defaulted in the past, but not the reason why the borrower defaulted.

[7] In other words, the bank receives the payment to which it is contractually entitled ($1 + r$) and all of the borrower's income ($1 + R$) is confiscated by the authorities, with an amount (R – r) being used to cover legal costs. This implies a monopolistic legal system in which lawyers set their fees to capture all of the money left over after compensating the bank.

(5) Honest and opportunistic borrowers with an approved loan invest the money.

(6) An honest borrower repays the loan, a dishonest borrower defaults, and an opportunistic borrower chooses whether to repay or to default.

(7) In the case of default, the banks seek compensation.

(8) Payoffs are realized.

Let $q \in \{0, 1\}$ denote an opportunistic borrower's decision whether to repay (q = 1) or to default (q = 0). Let $\xi \in \{0, 1\}$ be a bank's decision to screen, with $\xi = 1$ in the case of screening. Note that for screening to be worthwhile it must be unprofitable for the bank to lend to borrowers who are revealed not to be honest, and this requires a certain minimal proportion of dishonest borrowers.[8] Also, if the transaction cost t is too high then no-one will want to apply for a loan. In what follows, we assume that t is low enough and β high enough so that there is a market for loans and the screening technology is relevant. Solving the model backwards for pooling equilibria, we obtain the following result:

Proposition 1. There exist values $\underline{\lambda}$, $\overline{\lambda}$, $\overline{\beta}$ and $\overline{t}$ so that for $\beta \geq \overline{\beta}$ and $t \leq \overline{t}$, the unique equilibrium is:

[8] It turns out that in a model with no dishonest borrowers it will never be worthwhile to screen, because at levels of λ high enough to persuade the bank to lend to anyone at all it is also profitable to lend to borrowers who are revealed to be opportunistic, even if they all default and need to be prosecuted. Such a model is simpler than the one described in the main text and still implies the key result in equation (3) below. However, the complete irrelevance of the screening technology makes the simpler model somewhat unrealistic. Further details are available on request.

(i) The low default equilibrium (LDE) with $q = \xi = 1$, when $\lambda \geq \bar{\lambda}$.

(ii) The high default equilibrium (HDE) with $q = 0$ and $\xi = 1$, when $\underline{\lambda} \leq \lambda < \bar{\lambda}$.

(iii) The no lending equilibrium (NLE) with $\xi = 0$, when $\lambda < \underline{\lambda}$.

More details are given in Appendix 3.[9] Intuitively, the NLE occurs when contract enforcement is very weak. In such a situation, widespread default by opportunistic and dishonest borrowers makes lending unprofitable for any screening technology. Since we do observe some bank lending, even in countries with very weak institutions, the NLE is probably of theoretical interest only. The LDE occurs when there is a non-negligible proportion of dishonest borrowers ($\beta \geq \bar{\beta}$), so banks find screening to be worthwhile, but contract enforcement good enough to dissuade opportunistic borrowers from defaulting ($\lambda \geq \bar{\lambda}$). The HDE occurs within an intermediate range of contract enforcement quality, when default is not punished frequently enough to persuade opportunistic borrowers to repay the loan, but still frequently enough for lending to be profitable, as long as the banks use screening to weed out non-honest borrowers. Note that for all equilibria, the two banks set the same interest rate.

In Appendix 3 we derive an equation for $\bar{\lambda}$ which takes the following form:

$$\bar{\lambda} = \frac{1+r_i}{1+R}, \quad r_i = r_A = r_B \tag{1}$$

[9] The model in Appendix 3 also shows that the qualitative predictions of the theoretical model are unaltered when some banks are 'incompetent' (i.e. they have no access to the screening technology).

Equation (1) defines the minimal value of λ required for the market to be in the LDE: below this value, the HDE will obtain. Appendix 3 also includes an equation for the interest rate in the LDE:

$$1 + r_i = \frac{t - (\beta + \gamma)(1 + r_0)\sigma}{\alpha + (1 - \sigma)\gamma} \tag{2}$$

Note that the equilibrium interest rate is independent of the return *R*. Combining equations (1-2) we have:

$$\bar{\lambda} = \left[\frac{1}{1 + \mathrm{R}}\right]\left[\frac{t - (\beta + \gamma)(1 + r_0)\sigma}{\alpha + (1 - \sigma)\gamma}\right] \tag{3}$$

The two key country characteristics that we will be analyzing in the next section are the quality of governance (interpreted in our theoretical model as λ) and the magnitude of ethnic fractionalization (which we interpret as a correlate of the transaction cost *t*). Equation (3) implies that in (λ, *t*) space the LDE-HDE boundary will be an upward-sloping line, as shown in Figure 1. Higher values of *t* push up the boundary value of λ: a higher level of transaction cost gives more local monopoly power to the banks and pushes up the equilibrium interest rate; this makes opportunistic borrowers more likely to default at the margin, so better contract enforcement is required to maintain the LDE equilibrium.

Figure 1 describes a single sector of the economy in which all investment projects yield the same rate of return *R*. In this one sector, small changes in λ or *t* will have no effect on the default rate unless the starting point is very close to the boundary line. If the starting point is close to the boundary line, then a small change could take the sector across the line, with a very large change in the default rate.

However, different sectors are likely to have different rates of return and therefore different boundary lines. There will be a distribution of boundary lines, as illustrated by the grey area in Figure 2. Outside of the grey area, small changes in λ or t will still have no effect on the overall default rate in the economy, but inside the area there will be some effect, as the boundary line is crossed for some value of R. If the R-values are unimodally distributed, then the magnitude of the effect of a small change in λ or t will be greater when the starting point is closer to the modal boundary line (the black line in Figure 2). In other words, the response of the overall default rate to a small change in λ or t will be smaller when the starting point is further from the modal boundary line, i.e. when either λ is high and t is low, or λ is low and t is high.

This brings us to a set of specific empirical predictions about the relationship between the default rate, governance and ethnic fractionalization across countries and over time. Firstly, as long as some countries in some time periods fall within the grey area in Figure 2, we should see a negative correlation between the default rate and λ (governance), since a higher value of λ moves a country upwards towards the LDE space; we should see a positive correlation between the default rate and t (ethnic fractionalization), since a higher value of t moves a country rightwards towards the HDE space. These predictions are unremarkable, but we should also see that the size of the effects is greater in countries / time periods where there is either (i) relatively poor governance and relatively low fractionalization (the south-west of Figure 2) or (ii) relatively good governance and relatively high fractionalization (the north-east of Figure 2). To put it another way, the level of governance at which changes in governance matter depends on the level of fractionalization: the higher the level of fractionalization, the higher the level of governance at which there will be the most sensitivity of the default rate. In the next section we test this prediction using cross-country panel data.

III. Evidence

In this section we present tests of the predictions outlined above, using African panel data for 110 individual banks in 28 countries over 2000-2008 to fit a model of the loan default rate of each bank. Our predictions relate to the relationship between the default rate which a bank faces and the conditions of the market in which it operates, primarily the quality of governance and the level of ethnic fractionalization in the country. Our three key empirical variables are as follows:

(i) The default rate for bank *i* in year *y* ($default_{iy}$), measured as the ratio of impaired loans to total loans. The loans data are collated from the Bankscope database published by the Bureau van Dijk (https://bankscope.bvdinfo.com).

(ii) The quality of governance in each country *j* in year *y*, ($governance_{jy}$), measured as the first principal component of the following three variables in the World Bank's World Governance Indicators (WGI) database (http://info.worldbank.org/governance/wgi/): *control of corruption*, *rule of law* and *regulatory quality*.[10] *Control of corruption* measures 'the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state

[10] The WGI database includes three further measures: *political stability*, *voice and accountability* and *government effectiveness*. These are excluded from our aggregate governance measure because they are less likely to be directly associated with the quality of contract enforcement. However, this decision is not crucial to our results: the sample correlation between the measure of governance using three indicators and the measure using six indicators is 0.99, and replacing the three-indicator measure with the six-indicator one makes no substantial difference to our results.

by elites and private interests.' *Rule of law* measures 'the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.' *Regulatory quality* measures 'the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.' Further discussion of the construction of these variables appears in Kaufmann *et al*. (2009); we interpret each of the variables as a measure of some of the factors driving the probability (λ) that a bank will be able to enforce a loan contract if necessary. The variables are highly correlated in our sample, so it is not feasible to include more than one of them in any one model.[11] Nevertheless, we will also explore the sensitivity of our results to the way in which λ is measured by comparing the results using the principal component with results using any one of the three individual indicators instead.

(iii) The log of ethnic fractionalization in country *j* ($ethnic_j$). This variable measures ethnic diversity using a Herfindahl index: $ethnic_j = \ln\left(1 - \sum_{k=1}^{k=K} \left(s_{jk}\right)^2\right)$, where s_{jk} is the share of the k^{th} ethnic group in the total population of country *j*. Figures are taken from Alesina et *al*. (2003). Countries with more fractionalization are expected to have a higher financial transactions cost (*t*) on average.

Variables (i-iii) are the main variables of interest. However, our empirical model also includes a number of control variables. Firstly, there is likely to be some variation in

[11] The correlation coefficients are 0.93 for *control of corruption* and *rule of law*, 0.82 for *control of corruption* and *regulatory quality*, and 0.86 for *rule of law* and *regulatory quality*. The weights in the first principal component are almost uniform: 0.58 for *control of corruption*, 0.59 for *rule of law*, and 0.56 for *regulatory quality*.

the quality of banks' screening technology and therefore the default rate they face. The empirical model includes some bank characteristics that may be correlated with the quality of screening. Unless stated otherwise, these characteristics are measured using Bankscope data.

(iv) The age of bank *i* in year *y*, measured in years (age_{iy}), plus $(age_{iy})^2$. Older banks may have had time to acquire competence in the screening of customers, in which case we would expect the default rate to be decreasing in age. On the other hand, very new banks may have fewer informal connections with the political elite and come under less pressure to issue loans to customers of dubious creditworthiness, in which case we would expect the default rate to be increasing in age.

(v) The size of bank *i* in year *y*, measured by the logarithm of total bank assets ($assets_{iy}$), where asset values are expressed in 2005 US dollars. There may be economies of scale in screening, in which case the default rate should be decreasing in bank size.

(vi) The share of the government in ownership of bank *i* in year *y* ($government\text{-}ownership_{iy}$). Government-owned banks may make less effort to screen certain customers, either because of political patronage or because the government wishes to raise the volume of finance to investors, even at the expense of a high rate of default. In this case, the default rate should be increasing in the government ownership share.

(vii) An indicator variable which equals one if bank *i* in year *y* is foreign-owned and zero otherwise ($foreign\text{-}ownership_{iy}$). Foreign-owned banks may have access to better screening technology, so foreign ownership may be associated with a lower default rate. This measure is taken from Claessens and van Horen (2016).

In addition to these measures of bank-specific heterogeneity, the empirical model also includes five additional country-specific variables.[12]

(vii) The rate of growth of country *j*'s GDP between year $y - 1$ and year y ($growth\text{-}rate_{jy}$), where GDP is measured in 2005 US dollars, as reported in the World Bank's World Development Indicators (http://data.worldbank.org/products/wdi). A higher growth rate may be associated with a relative abundance of investment opportunities (i.e. a smaller proportion of dishonest borrowers) and a lower overall default rate.

(viii) The real exchange rate of country *j* in year *y* relative to the United States ($real\text{-}exchange\text{-}rate_{jy}$). This is measured as the GDP deflator for the country multiplied by the local currency / US Dollar exchange rate and divided by the US GDP deflator. Changes in the real exchange rate may reflect changes in aggregate competitiveness that are correlated the rate of return on investments and the propensity of firms to default on loans. Data are taken from the *Penn World Tables 8.1* (www.rug.nl/research/ggdc/data/pwt/pwt-8.1).

(ix) An indicator variable equal to one if country *j* is in North Africa and zero otherwise ($North\text{-}Africa_j$). The North African countries in our sample are Egypt,

[12] One variable that the model does not explicitly control for is 'excessive' lending by a bank. In fact very few banks in the sample have lending that is excessive by Western standards. For example, data in the Bureau van Dyk indicate that among US banks the value of the loan to assets ratio one standard deviation above the mean is 0.8. There are only 23 observations in our sample with a ratio this high, and only four with a ratio above 0.9. Excluding these observations does not make any substantial difference to our results.

Morocco and Tunisia. Data presented by Honohan and Beck (2007) indicate that the banking sector in North Africa differs from that in Sub-Saharan Africa in a number of key respects: North Africa has lower interest margins and wider access to financial services, and more closely resembles the banking sector of OECD countries. The *North-Africa* variable is intended to capture this heterogeneity.

(x) An indicator variable equal to one if country *j* is in the CFA Franc Zone and zero otherwise ($CFA\text{-}Zone_j$). Countries in the CFA Franc Zone are members of a monetary union with a trans-national banking regulation authority supported by the French Treasury. The distinctive prudential regulations of the CFA Franc Zone may be associated with a lower default rate, and we include this indicator variable in case $governance_{jy}$ does not fully capture these differences.

(xi) An indicator variable equal to one if country *j* is South Africa and zero otherwise ($South\text{-}Africa_j$). As a member of the G-20, South Africa is subject to higher banking regulation standards than most of the rest of Sub-Saharan Africa, and this may be associated with a lower default rate. We include this indicator variable in case $governance_{jy}$ does not fully capture these differences.

Summary statistics for the variables in the model are given in Table 1, which also includes information about the distribution of banks across the 28 countries in our sample. Missing observations for some banks in some years mean that we have an unbalanced panel with 527 observations in total. North Africa, the CFA Franc Zone and South Africa do represent rather different regulatory environments from the rest of Africa, and they also happen to have less ethnic fractionalization on average: the mean (standard deviation) of *ethnic* is –0.89 (1.03) in the full sample and –0.63 (0.69) when North African, CFA Franc Zone and South African banks are excluded.

Therefore, we will also report estimation results from a sub-sample of 368 observations that excludes these banks. Note also that *governance* and *ethnic* are not that highly correlated: using the principal component to measure *governance*, the full-sample correlation coefficient is only –0.27 and the restricted-sample correlation coefficient is only –0.02. Ethnic fractionalization is associated with somewhat poorer governance but the effect is not that strong, so we can hope to be able to identify separate effects for these two key explanatory variables.

Our empirical model is designed to test hypotheses about the effect on banks' loan default rates of the quality of governance (λ in the theoretical model, *governance* in the empirics) and ethnic fractionalization (t in the theoretical model, *ethnic* in the empirics). The theory implies that the effects will be non-linear, but first of all we test whether *governance* and *ethnic* have any impact on *default* on average. In order to do this, we note first of all that the dependent variable is limited to the interval [0,1]. An appropriate estimator for this type of limited dependent variable in a panel has been developed by Papke and Wooldridge (2008). Our underlying model is assumed to be of the form:

$$E\left[default_{iy}\right] = F\begin{pmatrix} \eta_i + \varphi_y + \theta_1 \cdot governance_{jy} + \theta_2 \cdot ethnic_j + \theta_3 \cdot age_{iy} \\ + \theta_4 \cdot \left(age_{iy}\right)^2 + \theta_5 \cdot assets_{iy} + \theta_6 \cdot government\text{-}ownership_{iy} \\ + \theta_7 \cdot foreign\text{-}ownership_{iy} + \theta_8 \cdot growth\text{-}rate_{jy} \\ + \theta_9 \cdot real\text{-}exchange\text{-}rate_{jy} + \theta_{10} \cdot North\text{-}Africa_j \\ + \theta_{11} \cdot CFA\text{-}Zone_j + \theta_{12} \cdot South\text{-}Africa_j \end{pmatrix}, \quad i \in j \qquad (4)$$

where F (.) is a cumulative density function, η_i is a bank random effect and φ_y is a year fixed effect. Following Papke and Wooldridge, we can estimate the θ parameters in equation (4) using a pooled fractional logit (or probit) model of *default* conditional on the eight explanatory variables plus the year fixed effects. Consistent estimates of the parameters are obtained by maximizing the Bernoulli log-likelihood function using a generalized linear model (GLM). The results below are based on estimates using the GLM routine in Stata 13; we report results from the logit version of the model, but the probit results are very similar.

Table 2 reports the estimates of the θ parameters in equation (1).[13] The first two columns of the table report the parameter estimates in the model using the principal component of the three WGI variables as the measure of governance, while subsequent columns report the estimates using the individual WGI variables instead. In each case, results are reported for the full sample of 527 observations and the sub-sample of 368 observations that excludes banks in North Africa, the CFA Franc Zone and South Africa. The table also includes the t-ratios for each parameter estimate, which are based on standard errors clustered at the bank level. Note that with a fractional logit model, the θ parameters in Table 2 are not equal to the marginal effects of each explanatory variable on the default rate. Therefore, the parameters do not necessarily indicate the relative importance of each variable. Estimates of the marginal effects will be discussed later, and at this point we discuss only the signs of the estimated parameters.

The first column of Table 2 shows that in the full-sample estimates using the principal component measure of governance, the only effects significant at the 5% level are for bank age, bank size, the North Africa dummy and CFA Franc Zone dummy: *ceteris paribus*, larger banks and banks in CFA countries have lower default rates on average, but banks in North Africa have higher ones. This last effect was

[13] The year fixed effects are jointly significant at the 1% level. They are not reported in the table, but are available on request.

not anticipated and deserves further study. Bank age has a non-linear effect, with maximal default rates at around 60 years of age. Conditional on these effects, there is a negative coefficient on the governance variable (as anticipated) that is significant at the 10% level, and a positive coefficient on ethnic fractionalization (as anticipated) that is insignificant. One potential explanation for the low significance levels of our two key variables is that the simple linear function does not fully capture their effect, a suspicion that is reinforced by the results in the second column, which shows significant governance and ethnic fractionalization effects in the restricted sample. In this sample there is a lower standard deviation of *ethnic*, so many outliers that would be particularly affected by non-linear effects are excluded. The restricted sample also produces significant government ownership and foreign ownership effects, again with the anticipated signs: government-owned banks have the highest default rates and foreign-owned ones the lowest. The subsequent columns in Table 2 (which report results using *rule of law* or *control of corruption* instead of the principal component measure) show similar increases in the significance level of estimated ethnic fractionalization effects when the sample is restricted, although now the governance effects are significant at the 5% level even in the full sample. The one governance measure that is never individually significant, even in the restricted sample, is *regulatory quality*.[14]

Our ethnic fractionalization measure and three out of our four measures of governance are significant determinants of loan default, at least in the restricted sample, and the relevant parameters have the expected signs in all cases. This

[14] This result contrasts with those in Andrianova *et al*. (2015), who find that *regulatory quality* has a significant effect on African banks' loan to deposit ratios. It is not clear why this measure of governance should be strongly correlated with loan to deposit ratios but not default rates, and this puzzle is to be the subject of future research.

suggests that our empirical measures are relevant to the theoretical quantities λ and t, and we now proceed to use these measures to test the predictions of the theoretical model about the interaction between the effects of governance and ethnic fractionalization. From now on we focus on governance as measured by the principal component of the three WGI indicators.

Our next step is to try to estimate how ∂*default*/∂*governance* and ∂ *default*/∂*ethnic* vary across different points in Figure 2. In order to do this, we need to parameterize the interaction between the *governance* and *ethnic* effects. One approach is to fit a model that includes additional terms in equation (4) that interact both *governance* and *ethnic* with the difference between the two, this difference being a measure of the distance from the dividing line in Figure 2. However, one complication with the construction of this difference is that *governance* is an index with an arbitrary mean and variance. We address this complication in two alternative ways. The first alternative is to construct a difference term based on standardized values of *governance* and *ethnic*:

$$difference_{jy} = \left| \frac{governance_{jy} - \mu_G}{\sigma_G} - \frac{ethnic_{jy} - \mu_E}{\sigma_E} \right|$$

Here, the μ and σ terms are the sample means and standard deviations of the relevant variables. Using this difference term assumes that the relative magnitudes of the standardized variables approximate to the relative magnitudes of λ and t in Figures 1-2 (and that the slope of the dividing line is close to one). Summary statistics for this measure of *difference* appear in Table 1.[15] The second alternative is to construct a difference term that is free of these assumptions, including scaling parameters φ and ξ that are to be estimated along with the θ parameters:

$$difference_{jy} = \left| \varphi + \xi \cdot governance_{jy} - ethnic_{jy} \right|$$

In both cases, the equation to be estimated is:

$$E\left[default_{iy}\right] = F\begin{pmatrix} \eta_i + \varphi_y + \theta_1 \cdot governance_{jy} + \theta_2 \cdot ethnic_j + \theta_3 \cdot age_{iy} \\ + \theta_4 \cdot \left(age_{iy}\right)^2 + \theta_5 \cdot assets_{iy} + \theta_6 \cdot government\text{-}ownership_{iy} \\ + \theta_7 \cdot foreign\text{-}ownership_{iy} + \theta_8 \cdot growth\text{-}rate_{jy} \\ + \theta_9 \cdot real\text{-}exchange\text{-}rate_{jy} + \theta_{10} \cdot North\text{-}Africa_j \\ + \theta_{11} \cdot CFA\text{-}Zone_j + \theta_{12} \cdot South\text{-}Africa_j \\ + \theta_{13} \cdot governance_{jy} \cdot difference_{jy} + \theta_{14} \cdot ethnic_j \cdot difference_{jy} \end{pmatrix}, \quad i \in j \qquad (5)$$

The parameters θ_{13} and θ_{14} capture the speed with which $\partial default/\partial governance$ and $\partial default/\partial ethnic$ fall as we move away from the dividing line in Figure 2. Given the predictions of the theoretical model, we can expect that $\theta_1 < 0 < \theta_2$ and $\theta_{13} > 0 > \theta_{14}$: larger absolute differences between the governance and ethnic fractionalization variables diminish the absolute size of the effect of both variables on loan default.

Table 3 shows five different sets of parameter estimates. Models B1 and B2 show the parameter estimates in equation (5) using the standardized values of *governance* and *ethnic* to construct the *difference* variable: Model B1 is fitted to the full sample while Model B2 is fitted to the restricted sample excluding banks in the

[15] There does not seem to be any obvious geographical pattern to the values of *difference*: all parts of Africa are represented among both the high-*difference* and low-*difference* groups.

CFA Franc Zone, North Africa and South Africa. Models A1 and A2 show analogous parameter estimates excluding the control variables (i.e. setting the parameters θ_3–θ_9 equal to zero). Model C shows the parameter estimates in equation (5) when the parameters φ and ξ are estimated.[16] Because the argument of *F*(.) in this model is non-linear, it is fitted only to the full sample: the restricted sample too small for a non-linear model to produce any significant parameter estimates.

Reading across the columns in Table 3, it can be seen that many of the effects of the control variables in Table 2 are also present here: the effect of bank age is non-monotonic (and significantly different from zero in the full-sample estimates), larger banks have lower default rates, government-owned banks have higher default rates, and North African Banks have higher default rates. However, the CFA Franc Zone effect is no longer statistically significant, which suggests that the non-linear effects in governance and ethnic fractionalization are capturing some of the heterogeneity that was previously captured by this indicator.

The signs of the four key parameter estimates (θ_1, θ_2, θ_{13}, θ_{14}) are consistent with our expectations in all five models. The sizes of the governance parameter estimates (θ_1 and θ_{13}) are very similar across all five sets of estimates and significant at the 5% level in all cases except for Model C, where the estimate of θ_{13} is somewhat less precise because the non-linear parameter φ is very imprecisely

[16] For given values of φ and ξ, the argument of *F*(.) in equation (5) is made up of linearly separable terms. The parameters in Model C are estimated by setting different values of φ and ξ, fitting a GLM model for each of these values, and then searching for the values of φ and ξ that are associated with the largest log-likelihood. The corresponding t-ratios are estimated using a bootstrap.

estimated.[17] Overall, the results can be read as evidence that the beneficial effects of governance on loan default are apparent only when governance and ethnic fractionalization are either both high or both low, as predicted by the theoretical model. The ethnic fractionalization parameter estimates (θ_2 and θ_{14}) are somewhat larger in the restricted sample than in the full sample. However, the restricted sample produces somewhat less precise estimates of these parameters, and the estimate of θ_{14} is statistically significant only in the full sample models (A1 and B1). Nevertheless, the significance of θ_{14} in Models A1 and B1 provide some evidence that the detrimental effects of ethnic fractionalization on loan default are apparent only when governance and ethnic fractionalization are either both high or both low, as predicted by the theoretical model.

The parameter estimates in Table 3 can be used to calculate the marginal effect of each variable on the default rate, i.e. $\theta_n \cdot F'$ evaluated at the mean value of *default*. For the linearly separable terms in the control variables, these marginal effects are also reported in Table 3. The marginal effects reported in the table imply that a 1% increase in the size of a bank (as measured by its asset base) reduces the default rate by about one third of a percentage point, and that a one percentage point increase in the share of the government in the bank's ownership increases the default rate by about three quarters of a percentage point (using the full sample) or 1.5 percentage points (using the restricted sample).

The marginal effects of *governance* and *ethnic* depend on *difference*, and Figures 3-4 use the full-sample estimates for Model B1 and Model C to show these

[17] The similarity between the Model A/B and Model C estimates is because (i) the means and standard deviations of *governance* and *ethnic* are very similar and (ii) the Model C estimate of φ is close to zero while the estimate of ξ is close to one.

effects for values of *difference* between zero and three (this maximum value corresponding approximately to the upper 95th percentile of the distribution of *difference* in both Model B1 and Model C). The black line in each figure indicates the estimated marginal effect for each level of *difference*, while the grey lines indicate the 95% confidence interval. Figure 3 shows that in a country with a minimal value of *difference*, a unit improvement in *governance* – i.e. an improvement equal to one standard deviation of the variable across the whole world – can be expected to reduce the default rate by about seven percentage points. At the mean value of *difference* (around 1.5) the effect is slightly less than half as large, and above the mean the effect becomes statistically insignificant. Figure 4 shows that in a country with a minimal value of *difference*, a 10% increase in ethnic fractionalization can be expected to raise the default rate by about 0.5 percentage points. The decline in the size of the effect is somewhat less marked than in Figure 3, and at the mean value of *difference*, a 10% increase in ethnic fractionalization raises the default rate by around 0.4 percentage points. Figure 5 shows an alternative set of results using the restricted-sample estimates for Model B2. These results are similar to those in Figures 3-4, except that the magnitude of the effects is somewhat larger. For example, a minimal value of *difference* is associated with a marginal effect for a unit increase in *governance* equal to about –11 percentage points and a marginal effect for a 10% increase in *ethnic* equal to about 1.2 percentage points.

IV. Discussion

The theoretical model presented in this paper shows that when a country's banking sector is characterized by market segmentation (which is one possible consequence of ethnic fractionalization), adverse selection and moral hazard, improvements in the quality of contract enforcement will sometimes – but not always – reduce the incidence of loan default. When segmentation is acute, it is at high initial levels of contract enforcement quality that marginal improvements in quality will make a difference; when segmentation is less severe, it is at low initial levels of contract enforcement quality that marginal improvements in quality will make a difference. Similarly, when the quality of contract enforcement is high, it is at high initial levels of segmentation that marginal changes in the level of segmentation will make a difference; when the quality of contract enforcement is low, it is at low initial levels of segmentation that marginal changes in the level of segmentation will make a difference. Analysis using African panel data for 110 individual banks in 28 countries over 2000-2008, provides support for these predictions. Using ethnic fractionalization as a proxy for the magnitude of market segmentation and World Bank governance indices to measure institutional quality, the empirical results show that the countries where loan defaults are most sensitive to differences in institutional quality or ethnic fractionalization are those where the levels of institutional quality and fractionalization are either both high or both low.[18]

These results suggest that discussions of the economic consequences of ethnic fractionalization need to be nuanced. In the context of loan defaults, a marginal increase in fractionalization has deleterious consequences only in *some* circumstances: namely, when the level of fractionalization is initially high (in countries with strong institutions) or when the level of fractionalization is initially low

[18] We are not the first to find threshold effects in the factors driving financial market characteristics. For example, Rioja and Valev (2004) and Demetriades and Law (2006) find that financial development has a larger impact on growth in middle-income or high-income countries, and is less important in low-income countries.

(in countries with weak institutions). Among both the most fortunate countries (low fractionalization, strong institutions) and among the least fortunate ones (high fractionalization, weak institutions), moderate differences in the level of fractionalization will not matter.

Our results could be interpreted as good news for policymakers in countries such as Senegal (with moderately high levels of both institutional quality and ethnic fractionalization) and Algeria (with moderately low levels of both). Our model predicts that in countries such as these, marginal improvements in institutional quality will have a marked effect on the loan default rate. What about countries with moderate levels of ethnic fractionalization and very low institutional quality (such as Zimbabwe), or with moderate levels of institutional quality and very low fractionalization (such as Tunisia)? Here, the model predicts that marginal improvements in institutional quality are unlikely to make much difference to the incidence of loan defaults. There are two possible responses to this observation. One is to suggest that these are the countries where there is a reason for the international community to make an especially large effort to promote substantial improvements in institutional quality that take the country a long way across Figure 2. Another is to suggest that if such large changes are infeasible in the short run, then the focus of attention should be on other determinants of loan default identified by our model, such as government ownership of banks and small bank size.

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TABLE 1

Summary statistics

(i) sample composition

	banks	*observations*		*banks*	*observations*
Angola	2	12	Mauritius	2	7
Benin	3	19	Morocco	1	2
Botswana	4	27	Mozambique	5	30
Cameroon	1	2	Namibia	3	9
CAR	1	6	Nigeria	4	26
Chad	1	4	Senegal	1	1
Egypt	4	18	Sierra Leone	1	3
Ethiopia	2	4	South Africa	9	40
Gabon	1	4	Sudan	1	3
Ghana	8	40	Swaziland	4	27
Kenya	14	80	Togo	2	6
Madagascar	1	4	Tunisia	10	57
Malawi	3	14	Zambia	4	12
Mauritania	1	6	Zimbabwe	17	64

(ii) distributions (sample size = 527)

	mean	*standard deviation*	*minimum*	*maximum*
default-rate	0.11	0.13	0.00	0.81
age	37.1	33.0	3	147
assets ÷ 100	0.08	0.04	-0.02	0.25
government-ownership	0.08		0	1
foreign-ownership	0.48		0	1
North-Africa	0.15		0	1
CFA-Zone	0.08		0	1
South-Africa	0.08		0	1
real-exchange-rate	0.37	0.14	0.14	0.99
growth-rate	0.04	0.06	-0.19	0.29
governance: principal component	-0.86	1.14	-3.08	1.44
governance: rule of law	-0.55	0.67	-1.72	0.90
governance: control of corruption	-0.48	0.65	-1.55	1.07
governance: regulatory quality	-0.45	0.74	-2.37	0.95
ethnic	-0.89	1.03	-3.23	-0.13

difference	1.46	0.94	0.01	3.66

TABLE 2

Estimated coefficients in the baseline model

T-ratios are given in italics.

	governance = principal component		*governance = rule of law*		*governance = control of corruption*		*governance = regulatory quality*	
	full sample	*restricted sample*	*full sample*	*restricted sample*	*full sample*	*restricted sample*	*full sample*	*restricted sample*
age	0.028	0.013	0.027	0.012	0.027	0.011	0.027	0.011
	2.28	*0.78*	*2.19*	*0.73*	*2.17*	*0.67*	*2.35*	*0.68*
(*age*)^2 ÷ 100	-0.024	-0.011	-0.024	-0.011	-0.023	-0.011	-0.024	-0.009
	-2.48	*-0.80*	*-2.40*	*-0.78*	*-2.38*	*-0.74*	*-2.55*	*-0.66*
assets ÷ 100	-0.054	-0.041	-0.053	-0.041	-0.054	-0.043	-0.051	-0.034
	-2.39	*-1.98*	*-2.38*	*-2.01*	*-2.43*	*-2.11*	*-2.20*	*-1.62*
government-ownership	0.832	1.898	0.882	2.042	0.832	2.050	0.794	1.711
	1.58	*2.53*	*1.67*	*2.72*	*1.54*	*2.73*	*1.56*	*2.24*
foreign-ownership	-0.340	-0.511	-0.321	-0.469	-0.306	-0.435	-0.389	-0.633
	-1.33	*-2.24*	*-1.28*	*-2.20*	*-1.23*	*-2.09*	*-1.47*	*-2.52*
real-exchange-rate	0.110	-1.252	0.065	-1.330	0.144	-1.343	-0.115	-1.367
	0.16	*-1.62*	*0.09*	*-1.77*	*0.21*	*-1.85*	*-0.15*	*-1.55*
growth-rate	0.841	1.820	0.865	1.953	0.801	1.833	0.366	1.364
	0.64	*1.51*	*0.66*	*1.62*	*0.61*	*1.57*	*0.27*	*1.11*
North-Africa	1.257		1.347		1.250		1.128	
	2.22		*2.43*		*2.35*		*1.87*	
CFA-Zone	-0.801		-0.777		-0.556		-1.056	
	-2.36		*-2.52*		*-1.64*		*-2.96*	
South-Africa	0.109		0.102		0.107		0.141	
	0.34		*0.31*		*0.33*		*0.46*	
governance	-0.159	-0.187	-0.346	-0.428	-0.447	-0.526	-0.018	-0.040
	-1.85	*-2.11*	*-2.70*	*-2.72*	*-3.05*	*-3.17*	*-0.11*	*-0.26*
ethnic	0.245	0.726	0.239	0.702	0.174	0.626	0.274	0.728
	1.56	*2.78*	*1.55*	*3.02*	*1.18*	*2.83*	*1.63*	*2.65*
sample size	527	368	527	368	527	368	527	368
log-likelihood	-128.7	-83.1	-128.4	-82.8	-128.2	-83.1	-129.1	-83.5

TABLE 3

Estimated coefficients in the model with interaction terms

T-ratios are given in italics; 'm.e.' denotes marginal effects.

	Model A1		Model A2		Model B1		Model B2		Model C	
	φ and ξ fixed full sample no controls		*φ and ξ fixed restricted sample no controls*		*φ and ξ fixed full sample with controls*		*φ and ξ fixed restricted sample with controls*		*φ and ξ estimated full sample with controls*	
	coef.	*m.e.*	*coef.*	*m.e.*	*coef.*	*m.e.*	*coef.*	*m.e.*	*coef.*	*m.e.*
age					0.022	0.0013	-0.001	-0.0001	0.021	0.0013
					1.91		*-0.06*		*1.57*	
(age)^2 ÷ 100					-0.020	-0.0011	0.001	0.0001	-0.019	-0.0011
					-2.13		*0.06*		*-1.76*	
assets ÷ 100					-0.053	-0.003	-0.038	-0.003	-0.051	-0.003
					-2.54		*-1.92*		*-2.31*	
government-ownership					1.324	0.076	1.974	0.150	1.298	0.075
					2.61		*2.62*		*1.84*	
foreign-ownership					-0.195	-0.011	-0.645	-0.049	-0.194	-0.011
					-0.82		*-2.85*		*-0.70*	
real-exchange-rate					0.337	0.019	-0.543	-0.041	0.170	0.010
					0.45		*-0.70*		*0.16*	
growth-rate					0.590	0.034	2.107	0.160	0.180	0.010

					0.46		*1.77*		*0.11*	
North-Africa	1.978	0.114			1.346	0.078			1.287	0.074
	3.56				*1.85*				*1.41*	

TABLE 3 (continued)

	Model A1		Model A2		Model B1		Model B2		Model C	
	φ and ξ fixed *full sample* *no controls*		*φ and ξ fixed* *restricted sample* *no controls*		*φ and ξ fixed* *full sample* *with controls*		*φ and ξ fixed* *restricted sample* *with controls*		*φ and ξ estimated* *full sample* *with controls*	
	coef.	*m.e.*	*coef.*	*m.e.*	*coef.*	*m.e.*	*coef.*	*m.e.*	*coef.*	*m.e.*
CFA-Zone	0.077	0.004			-0.154	-0.009			-0.166	-0.010
	0.19				*-0.53*				*-0.43*	
South-Africa	-0.159	-0.009			0.007	0.000			0.112	0.007
	-0.59				*0.02*				*0.20*	
governance	-1.183		-1.123		-1.278		-1.414		-1.395	
	-4.27		*-2.82*		*-4.98*		*-3.72*		*-2.70*	
ethnic	1.059		1.762		0.986		1.602		1.047	
	2.46		*1.74*		*3.02*		*1.92*		*1.36*	
governance × difference	0.549		0.540		0.556		0.688		0.444	
	3.48		*2.25*		*3.83*		*3.05*		*1.45*	

ethnic × difference	-0.199	-0.501	-0.250	-0.625	-0.257
	-1.70	*-0.94*	*-1.92*	*-1.41*	*-1.24*
φ					0.1
					0.31
ξ					1.2
					2.36
sample size	527	368	527	368	527
log-likelihood	-129.9	-85.6	-126.0	-81.9	-125.8

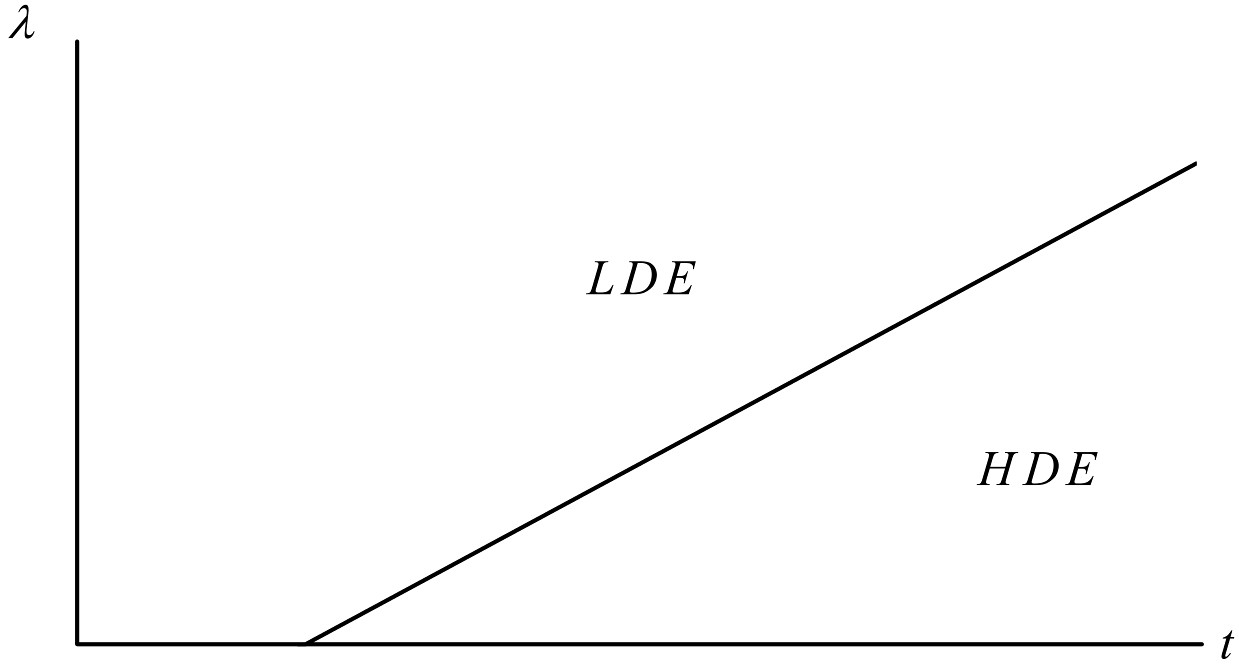

Figure 1. The boundary between the LDE and HDE spaces for a single sector.

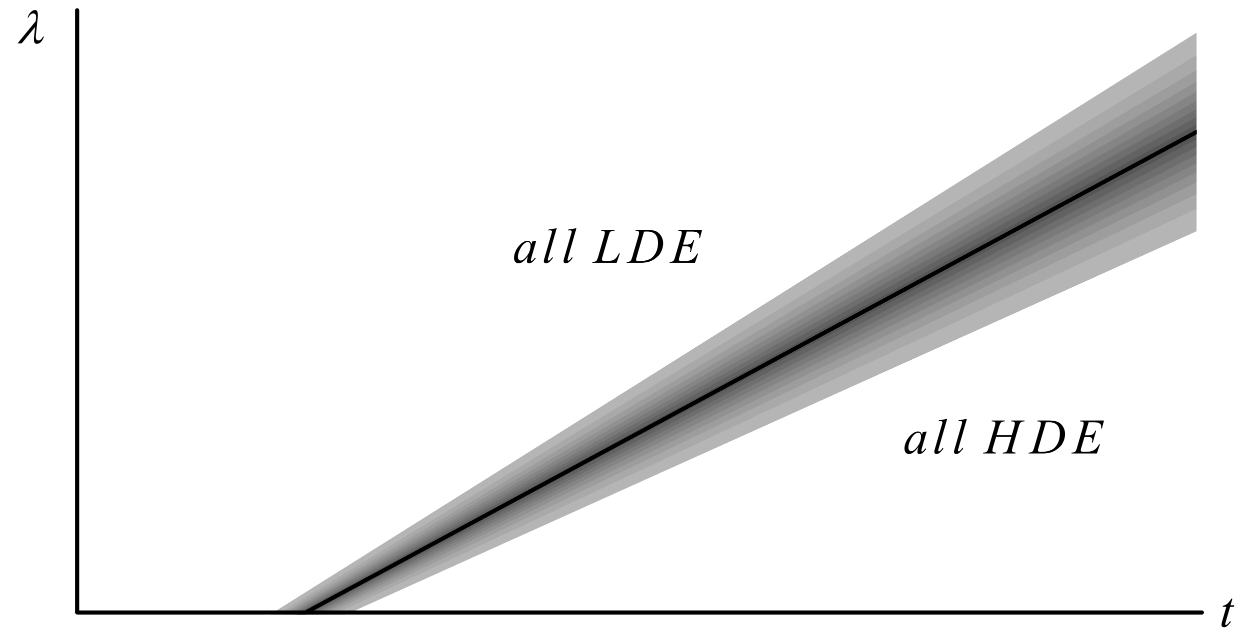

Figure 2. The boundaries between the LDE and HDE spaces across all sectors.

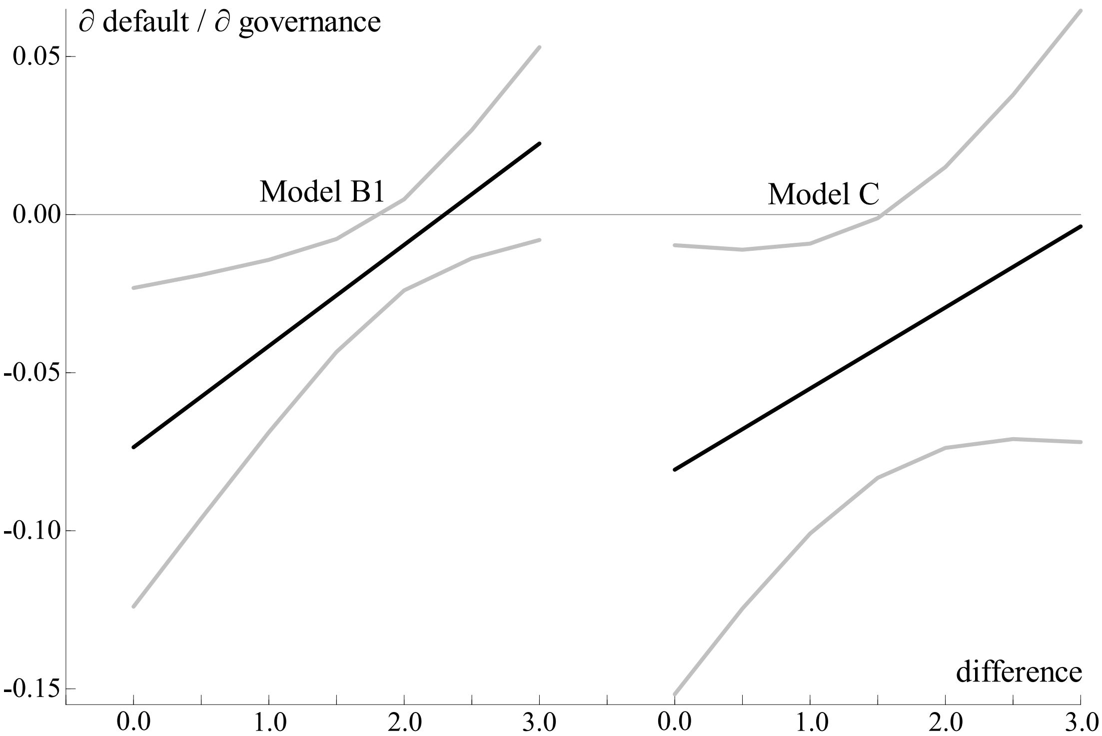

Figure 3.Estimated governance effects with 95% confidence intervals (Models B1 and C).

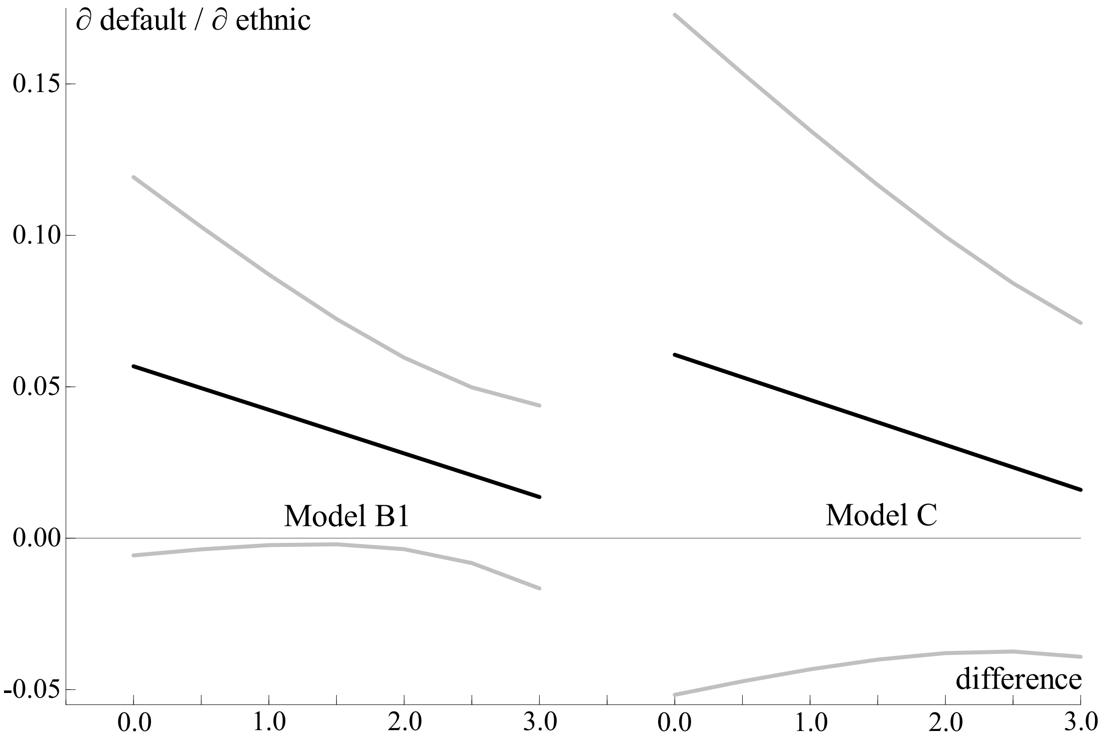

Figure 4. Estimated ethnic fractionalization effects with 95% confidence intervals (Models B1 and C)

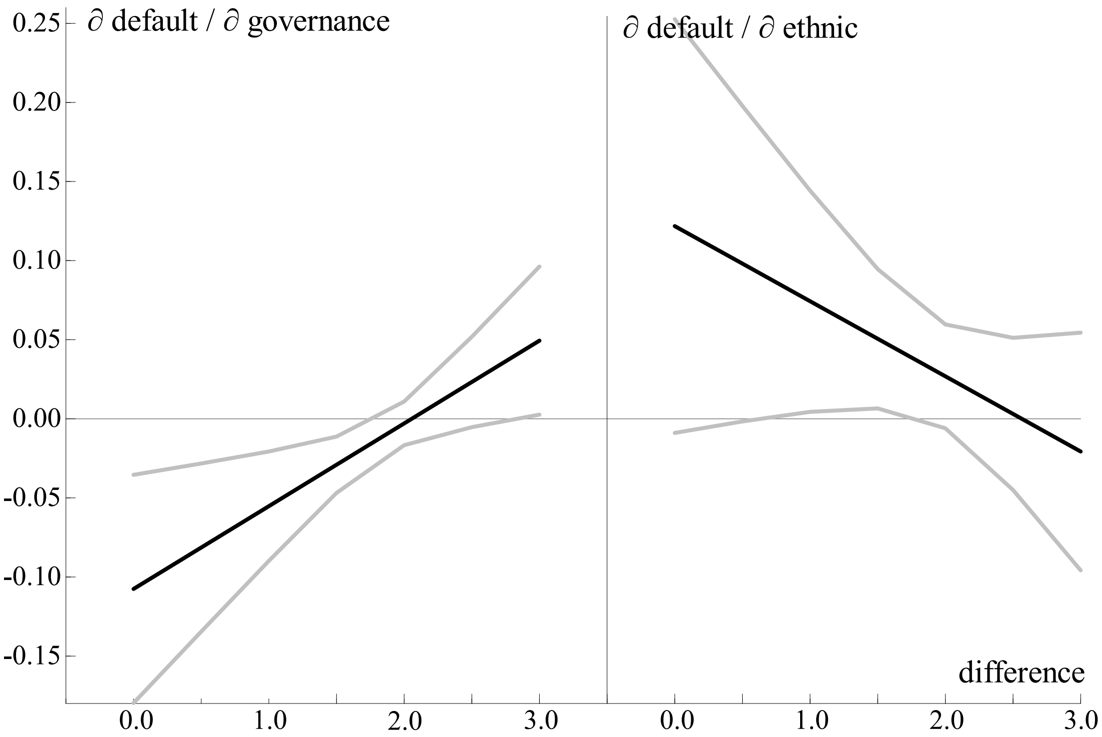

Figure 5. Estimated governance and ethnic fractionalization effects with 95% confidence intervals (Model B2)

Appendix 1: Evidence on the Ethnic Differentiation of Banks

This appendix presents evidence suggesting that there is at least one part of Africa where banks are ethnically differentiated. Ideally, we would like to have data on the ethnicity of bank staff and directors, but as far as we know such data are not available for any country in Africa. Instead we examine the factors driving the location of bank branches, one key factor being the ethnic composition of each locality. *Ceteris paribus*, if a bank is more (less) likely to locate in an area dominated by a particular ethnic group then this suggests that there is a particularly strong (weak) association between the bank and the group. If these effects vary across banks then we might suppose that banks are ethnically differentiated.

Although comprehensive bank branch data are available for relatively few countries in Africa, one region with good data is the West African Economic and Monetary Union (Benin, Côte d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal and Togo). The Central Bank of West African States provides annual branch location data for each bank in each country.[19] Although banks in most of these countries do not have enough branches for a robust statistical analysis,[20] Côte d'Ivoire does have enough branches to support such an analysis.

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[19] The WAEMU forms one half of the CFA Franc Zone. The branch location data we us are in the 2014 edition of the *Annuaire des Banques et Etablissements Financiers*.

[20] In Burkina Faso the largest bank has 27 branches and the next largest has 17. The corresponding figures for the other countries are as follows – Guinea-Bissau: seven and three; Mali: 24 and 14; Niger: eight and five; Senegal: 17 and 16; Togo: 23 and 21. A large proportion of these branches are in the largest urban centres where almost all banks are represented; although there is some cross-bank variation in the location of branches in

Our statistical model of Ivorian bank branch location is designed to explain the probability that a particular bank (*i*) will have a branch in a particular département (*j*). (The département is the standard regional administrative unit: there are 107 départements across Côte d'Ivoire.) We exclude départements with over 450,000 inhabitants (Abidjan, Bouaké, Daloa, Gagnoa, Korhogo, San-Pédro, and Soubré,) and also the département containing the national administrative capital, Yamoussoukro. All of the major banks have branches in all of these départements. We also exclude 11 small rural départements for which the ethnic composition data described below are unavailable. The seven banks in our sample are Banque Atlantique, NSIA Banque, Banque Internationale pour le Commerce et l'Industrie, Banque Nationale d'Investissement, Société Génerale de Banques, Société Ivoirienne de Banque, and Caisse Nationale des Caisses d'Epargne. These are the only banks with at least five branches outside the eight départements named above; the number of branches of each bank is noted in Table A1.

Our statistical model controls for the total population of the département, the share of the population living in urban areas, and the distance between the département capital and Abidjan (the national commercial capital); population figures are taken from the 2014 census. In addition to these characteristics, we construct a series of measures designed to capture the ethnic composition of département: the proportion of the population who are Gur, the proportion who are Kwa, the proportion who are Kru and the proportion who are Mande (the omitted category is non-

smaller centres, the total numbers are too small for there to be much power in a statistical test of the size of this variation.

Ivorians). These measures are constructed using the 2012 Demographic Health Survey for Côte d'Ivoire.[21] The model of branch location is as follows:

$$P\left(x_{ij} = 1\right) = F\left(\sum_i \left(\alpha_i + \sum_k \beta_{ik} \cdot s_{jk}\right) + \sum_p \gamma_p \cdot z_{jp} + \varepsilon_{ij}\right) \quad \text{(A1)}$$

where x_{ij} is an indicator variable for the presence of a branch of bank i in département j, s_{jk} is the share of ethnicity k in the population of département j ($k \in$ {Gur, Kru, Kwa, Mande}), z_{jp} stands for the control variables ($p \in$ {log of population, log of the share of the population living in urban areas, log of distance to Abidjan}), and ε_{ij} is an error term. F(.) stands for the logistic function.[22] This model with bank-specific ethnicity effects (β_{ik}) can be tested against a simple model with uniform ethnicity effects across banks (β_k):

$$P\left(x_{ij} = 1\right) = F\left(\sum_i \alpha_i + \sum_k \beta_k \cdot s_{jk} + \sum_p \gamma_p \cdot z_{jp} + \varepsilon_{ij}\right) \quad \text{(A2)}$$

The difference in the log-likelihood between the two models can then be used to compute a χ^2 test of the joint significance of the bank-specific ethnicity effects: in

[21] The survey notes the ethnicity of each household at each sample point, and the sample points are geocoded. We compute the total share of each ethnicity k at each sample point and use the geocoding to match each sample point to the nearest département capital. The share of each ethnicity k in each département is computed as the average of all sample points associated with the relevant département capital. The 11 départements excluded from our dataset are ones with no nearby sample point. Our four broad ethnic groups are aggregates of 60 smaller groups listed in the survey: the smaller groups are aggregated to broad groups using information in the *Ethnologue* database (www.ethnologue.com).

[22] It is also possible to allow the effects of the other relevant characteristics z to vary across banks; however, these bank-specific effects are not statistically significant.

other words, a test of the hypothesis that there is cross-bank heterogeneity in the effect of ethnicity on branch location.

Table A1 reports estimates of the α_i, β_{ik} and γ_p parameters in equation (A1), along with the corresponding t-ratios, and also odds ratios for a one percentage point change in each ethnic share and a 1% change in population, urbanization and distance to Abidjan. It can be seen that total population and urbanization both have strong positive effects on the probability that a bank will locate in a département, and that distance to Abidjan has a strong negative effect. Conditional on these effects, there are a number of statistically significant bank-specific ethnicity effects. In particular, NSIA Banque and Caisse Nationale are less likely to locate in a département dominated by the Gur or Kwa, and Banque Nationale is less likely to locate in a département dominated by the Kru. More importantly, the χ^2 test indicates that the bank-specific ethnicity effects are jointly significant at the 1% level. In other words, there is significant cross-bank heterogeneity in the effect of ethnicity on branch location: some banks are more strongly associated with some ethnic groups than with others, and these effects vary across banks.

Appendix 2: Ethnic Fractionalization and Transaction Cost

This appendix illustrates the argument outlined in footnote 4 of the main text: a relatively high level of ethnic fractionalization in a town implies that the average ethnic group size is relatively low. If each bank is connected to a specific ethnic group, and locates in the town only if the size of its group is above a certain threshold level, then a low average group size makes it more likely that there are ethnic groups which are too small for 'their' banks to operate in the town. These groups will have to deal with banks other than their own, and if this is associated with a higher transaction cost then a higher level of fractionalization will be associated with a higher cost.

We illustrate this argument using a numerical example. Suppose that there are four distinct ethnic groups and five banks. One of the banks (which could be thought of as an 'international' bank) is not connected to any ethnic group; this bank conducts operations regardless of the relative sizes of the different ethnic groups. A customer dealing with this bank incurs a transaction cost of one unit. Each of the other four banks is connected to a different ethnic group, and a customer dealing with the bank that matches her ethnicity incurs no transaction cost. Also, the ethnic groups are clustered: groups 1 and 2 are similar, and groups 3 and 4 are similar. A customer from group 1 dealing with the bank attached to group 2 incurs a transaction cost of 0.5 units, and similarly for the other groups, as outlined in Table A2. Finally, an ethnic bank conducts operations only if its group constitutes more than a certain threshold proportion of the population. We consider three alternative thresholds: 0.2, 0.3 and 0.4.

The number of banks in operation depends on the sizes of the different ethnic groups, as illustrated in Table A3. Each row of the table relates to a different possible combination of ethnic group sizes; in each case, the size of group 1 ≥ the size of group 2 ≥ the size of group 3 ≥ the size of group 4. The table covers all permutations in which the size of each group is a multiple of 0.1. The first four columns of the table indicate the size of each group in each case, and the fifth column the corresponding level of ethnic fractionalization, i.e. the probability that two individuals drawn at random from the population will be members of different ethnic groups. The sixth column notes the number of ethnic banks in operation in each case when the threshold is 0.2. The seventh column notes the average transaction cost when the threshold is 0.2, calculated as the cost for each ethnic group multiplied by the share of that group in the total population. Subsequent columns note the number of ethnic banks and average transaction cost for larger threshold values (but omitting those cases where no ethnic bank is in operation and so there is no competition between banks).

The final row of the table notes the correlation between the values in the ethnic fractionalization column and the values in each transaction cost column. For every threshold value the correlation is positive, i.e. a higher level of fractionalization is associated with a larger average transaction cost. Higher threshold values increase the strength of this association.

Appendix 3: Derivation of Proposition 1

In this derivation, we firstly set out the payoffs of all players and then establish the conditions which deliver the stated pooling equilibria. As indicated in footnote 8, the results are qualitatively unaltered if we allow for some banks who are ‘incompetent’ and have no access to the screening technology. In the equations below, κ represents the proportion of competent banks and p_κ ($p_{1-\kappa}$) represents the lending decision of a competent (incompetent) bank, with p = 1 in the case of lending. A bank’s type is unknown to the borrowers, but the proportion κ is public information. The expected payoff of a borrower of each type from applying for a loan to bank i ($i \in \{A, B\}$) is as follows:

$$U_i^\alpha = \left[\kappa\left(\xi + (1-\xi)\,p_\kappa\right) + (1-\kappa)\,p_{1-\kappa}\right]\left[\mathrm{R} - r_i\right] - tx_i^\alpha \tag{A3}$$

$$U_i^\beta = \left[\kappa\left(\xi(1-\sigma) + (1-\xi)\,p_\kappa\right) + (1-\kappa)\,p_{1-\kappa}\right] - tx_i^\beta \tag{A4}$$

$$\begin{aligned} U_i^\gamma = &\left[\kappa\left(\xi(1-\sigma) + (1-\xi)\,p_\kappa\right) + (1-\kappa)\,p_{1-\kappa}\right] \\ &\times\left[(1+\mathrm{R})\left(1-\lambda(1-q)\right) - q(1+r_i)\right] - tx_i^\gamma \end{aligned} \tag{A5}$$

where $x_i^{\{.\}}$ stands for the distance between a borrower of type $\{.\}$ and bank i, and $x_B^{\{.\}} = 1 - x_A^{\{.\}}$. The payoff to a bank of a given type is written as:

$$V_i^\kappa = D_i\left[\begin{array}{l} \xi\left((1+r_i)\left(\alpha + \gamma(1-\sigma)\left(q + \lambda(1-q)\right)\right) + (1+r_0)(\beta+\gamma)\sigma\right) \\ +(1-\xi)\left(p_\kappa(1+r_i)\left(\alpha + \left(q + (1-q)\lambda\right)\gamma\right) + (1-p_\kappa)\left[1+r_0\right]\right) \end{array}\right] \tag{A6}$$

$$V_i^{1-\kappa} = D_i\left[p_{1-\kappa}(1+r_i)\left(\alpha+\left(q+(1-q)\lambda\right)\gamma\right)+(1-p_{1-\kappa})\left[1+r_0\right]\right] \quad \text{(A7)}$$

where D_i is the demand for bank i loan contracts. The LDE is defined as an equilibrium with q^* = 1, ξ^* = 1 and $p_{1-\kappa}^*$ = 1. For q^* = 1, we check that a γ-type borrower will not want to deviate by choosing q = 0 when ξ^* = 1 and $p_{1-\kappa}^*$ = 1:

$$U_i^{\gamma}\left(q=1 \mid \xi=1, p_{1-\kappa}=1\right) \geq U_i^{\gamma}\left(q=0 \mid \xi=1, p_{1-\kappa}=1\right) \quad \text{(A8)}$$

This implies:

$$(1-\kappa\sigma)(\mathrm{R}-r_i)-tx_i^{\gamma} \geq (1-\kappa\sigma)(1-\lambda)(1+\mathrm{R})-tx_i^{\gamma} \quad \text{(A9)}$$

$$\lambda \geq \frac{1+r_i}{1+\mathrm{R}}=\bar{\lambda} \quad \text{(A10)}$$

where $\bar{\lambda}$ is the LDE boundary value for λ in Proposition 1 and equation (1) of the main text. A competent bank will choose ξ^* = 1 when $V_i^{\kappa}\left(\xi=1 \mid q^*=1, p_{\kappa}^*\right) \geq V_i^{\kappa}\left(\xi=0 \mid q^*=1, p_{\kappa}^*\right)$. This implies:

$$\beta \geq \frac{(r_i-r_0)\gamma}{1+r_0}=\bar{\beta} \quad \text{(A11)}$$

We will now show that r_i is independent of R and therefore uniform across all sectors of the economy (as long as the sectors differ only in their rate of return). In order to find the equilibrium value of r_i, write the total demand for bank i loan contracts as:

$$D_i = \alpha D_i^{\alpha} + \beta D_i^{\beta} + \gamma D_i^{\gamma} \tag{A12}$$

i.e. the sum of total demand per type of borrower. These levels of demand are determined by the marginal borrower of each type. In equilibrium, each type of marginal borrower is indifferent between going to bank *A* or bank *B* for a loan. For the marginal honest borrower this gives:

$$x_A^{\alpha} = \frac{1}{2} - \frac{r_A - r_B}{2t} \tag{A13}$$

Similarly, the condition for the marginal opportunistic borrower is given by:

$$x_A^{\gamma} = \frac{1}{2} - \frac{r_A - r_B}{2t}\left(1 - \kappa\sigma\right) \tag{A14}$$

If the marginal dishonest borrower is located exactly in the middle of the interval between the two banks has a non-negative payoff, then every dishonest borrower will apply to the nearest bank. This translates into:

$$x_A^{\beta} = \frac{1}{2} \quad when \quad \kappa\sigma \;\geq\; 1 - \frac{t}{2} \tag{A15}$$

Collecting the terms and making the required assumptions, we have:

$$D_A = \frac{1}{2}\left[1 - \frac{\left(\alpha + \left(1 - \kappa\sigma\right)\gamma\right)\left(r_A - r_B\right)}{t}\right] \tag{A16}$$

Substituting this into competent bank's payoff and solving the first order condition for a symmetric solution ($r_A = r_B$), it can be checked that:

$$1+r_i = 1+r_A^* = 1+r_B^* = \frac{t}{\alpha+(1-\kappa\sigma)\gamma} - \frac{(\beta+\gamma)(1+r_0)\sigma}{\alpha+(1-\sigma)\gamma} \tag{A17}$$

Setting $\kappa = 1$ gives us equation (2) of the main text. Note that the right hand side of the equation is independent of *R*. To ensure that all opportunistic borrowers apply for a loan (i.e. that the marginal opportunistic borrower is located in the middle of the interval), it is sufficient to assume that $t \leq (1-\alpha)(1+r_0)\sigma = \bar{t}$, where $\bar{t}$ is the boundary value for *t* in Proposition 1 of the main text. Note that when the participation constraint of the marginal opportunistic borrower is satisfied, so also will be the participation constraint of the marginal honest borrower (because the expected payoff for an honest borrower in the LDE is higher than the payoff for an opportunistic borrower located at the same point). The stricter of the two conditions on *t* will ensure that borrowers of every type apply. To solve for the HDE with $q^* = 0$, $\xi = 1$ and $p_{1-\kappa} = 1$, repeat the steps of the solution for the LDE. Opportunistic borrowers chose $q^* = 0$ when the reverse of (A10) holds. The competent type of bank still prefers to screen all its loan applications if (A11) holds. Additionally, in this case, given that $q^* = 0$, the competent bank prefers screening and lending to those with an untainted record over not screening and not lending to any borrower: $V_{ij}^{\kappa}(\xi^* = 0 \mid q^* = 1) \geq V_{ij}^{\kappa}(\xi = 0, p_\kappa = 0 \mid q^* = 0)$. This implies:

$$\lambda \geq \left[\frac{(1-(1-\alpha)\sigma)(1+r_0)}{(1+r_{Aj})} - \alpha\right]\left[\frac{1}{(1-\sigma)\gamma}\right] = \underline{\lambda} \tag{A18}$$

where $\underline{\lambda}$ is the HDE boundary value for λ in Proposition 1 of the main text. Since opportunistic borrowers do not repay their loans in the HDE, their expected payoff no longer depends on r_{ij} and therefore the marginal borrowers of each type in the HDE are given by (A13), (A15) and:

$$x^{\gamma}_{Aj} = \frac{1}{2} \quad when \quad (1-\kappa\sigma)(\mathrm{R}-r_A) \geq \frac{t}{2} \tag{A19}$$

Solving for r_{Aj} from the first order condition of the expected payoff maximisation of the competent bank and assuming a symmetric solution, the equilibrium interest rate in the HDE is:

$$1+r_{ij} = 1+\overset{*}{r}_{Aj} = 1+\overset{*}{r}_{Bj} = \frac{2t}{\alpha} - \frac{(1-\alpha)(1+r_0)\sigma}{\alpha+(1-\sigma)\gamma\lambda} \tag{A20}$$

The right hand side of the equation is again independent of *j*. To complete the proposition, the NLE obtains when the competent bank finds it more profitable to invest the loanable funds into the safe asset rather than to make loans: $V^{\kappa}_{ij}(\xi^{*}=1 \mid q^{*}=0) < V^{\kappa}_{ij}(\xi=0, p_{\kappa}=0 \mid q^{*}=0)$, which is the reverse of (A18).

TABLE A1

Estimated effects in the model of Ivorian bank branch location (7 banks × 88 départements)

T-ratios are given in italics. 'Branches' refers to the number of départements with branches, excluding the eight main centres.

Bank-specific effects (β parameters)	*Gur share* coef.	*Gur share* odds	*Kru share* coef.	*Kru share* odds	*Kwa share* coef.	*Kwa share* odds	*Mande share* coef.	*Mande share* odds	*intercept (α)* coef.	branches
Banque Atlantique	1.236 *0.61*	1.012	-0.107 *-0.06*	0.999	2.945 *1.31*	1.030	0.531 *0.24*	1.005	-27.67 *-6.86*	22
NSIA Banque	-4.981 *-2.95*	0.951	0.182 *0.14*	1.002	-7.472 *-1.76*	0.928	-0.514 *-0.27*	0.995	-27.11 *-6.85*	13
Banque Internationale pour le Commerce	1.249 *0.38*	1.013	0.841 *0.29*	1.008	-5.945 *-0.78*	0.942	1.175 *0.32*	1.012	-29.75 *-6.23*	6
Banque Nationale d'Investissement	-0.244 *-0.10*	0.998	-3.451 *-1.97*	0.966	-7.406 *-1.36*	0.929	-5.643 *-1.58*	0.945	-26.61 *-6.58*	7
Société Génerale de Banques	-0.009 *-0.00*	1.000	-0.851 *-0.59*	0.992	-7.004 *-1.60*	0.932	-1.526 *-0.86*	0.985	-27.42 *-6.73*	11
Société Ivoirienne de Banque	1.339 *0.61*	1.013	-1.939 *-0.85*	0.981	-8.272 *-0.93*	0.921	-0.534 *-0.20*	0.995	-28.77 *-6.66*	5
Caisse Nationale des Caisses d'Epargne	-4.970 *-2.15*	0.952	-1.237 *-0.58*	0.988	-4.170 *-1.79*	0.959	-4.117 *-1.80*	0.960	-21.32 *-5.46*	60

Aggregate effects (γ parameters)	*log total pop.* coef.	*log total pop.* odds	*log urbanization* coef.	*log urbanization* odds	*log dist.to Abidjan* coef.	*log dist.to Abidjan* odds
	2.465 *7.69*	1.025	2.407 *5.26*	1.024	-0.995 *-4.08*	0.990

Joint significance of regressors: $\chi^2(37) = 167.5$ ($p < 0.01$)

Joint sig. of bank-specific effects: $\chi^2(24) = 45.3$ ($p < 0.01$)

TABLE A2

Transaction cost for each ethnic group when dealing with each bank

	Group 1	*Group 2*	*Group 3*	*Group 4*
Bank 1	0.0	0.5	1.0	1.0
Bank 2	0.5	0.0	1.0	1.0
Bank 3	1.0	1.0	0.0	0.5
Bank 4	1.0	1.0	0.5	0.0

TABLE A3

Ethnic fractionalization and transaction cost

share of ethnic group 1	share of ethnic group 2	share of ethnic group 3	share of ethnic group 4	ethnic fraction-alization	threshold = 0.2 number of ethnic banks	threshold = 0.2 average cost	threshold = 0.3 number of ethnic banks	threshold = 0.3 average cost	threshold = 0.4 number of ethnic banks	threshold = 0.4 average cost
1.0	0.0	0.0	0.0	0.00	1	0.00	1	0.00	1	0.00
0.9	0.1	0.0	0.0	0.18	1	0.05	1	0.05	1	0.05
0.8	0.2	0.0	0.0	0.32	1	0.10	1	0.10	1	0.10
0.8	0.1	0.1	0.0	0.34	1	0.15	1	0.15	1	0.15
0.7	0.3	0.0	0.0	0.42	2	0.00	1	0.15	1	0.15
0.7	0.2	0.1	0.0	0.46	1	0.20	1	0.20	1	0.20
0.7	0.1	0.1	0.1	0.48	1	0.25	1	0.25	1	0.25
0.6	0.4	0.0	0.0	0.48	2	0.00	2	0.00	1	0.20
0.6	0.3	0.1	0.0	0.54	2	0.10	1	0.25	1	0.25
0.6	0.2	0.2	0.0	0.56	1	0.30	1	0.30	1	0.30
0.6	0.2	0.1	0.1	0.58	1	0.30	1	0.30	1	0.30
0.5	0.5	0.0	0.0	0.50	2	0.00	2	0.00	2	0.00
0.5	0.4	0.1	0.0	0.58	2	0.10	2	0.10	1	0.30
0.5	0.3	0.2	0.0	0.62	2	0.20	1	0.35	1	0.35
0.5	0.3	0.1	0.1	0.64	2	0.20	1	0.35	1	0.35
0.5	0.2	0.2	0.1	0.66	1	0.40	1	0.40	1	0.40
0.4	0.4	0.2	0.0	0.64	2	0.20	2	0.20		
0.4	0.4	0.1	0.1	0.66	2	0.20	2	0.20		
0.4	0.3	0.3	0.0	0.66	3	0.00	1	0.45		
0.4	0.3	0.2	0.1	0.70	2	0.30	1	0.45		
0.4	0.2	0.2	0.2	0.72	1	0.50	1	0.50		
0.3	0.3	0.3	0.1	0.72	3	0.05				
0.3	0.3	0.2	0.2	0.74	2	0.40				
correlation between ethnic fractionalization and average cost						0.54		0.73		0.83