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Borders, Ethnicity and Trade

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May 2012

Abstract

Do traders incur additional costs for their cross-border trade in sub-Saharan Africa? This paper uses unique high-frequency data on prices of two agricultural goods to examine the additional costs incurred in cross-border trade between Niger and Nigeria, as well as trade between ethnically distinct markets within Niger. We find a sharp and significant conditional price change of about 20 to 25 percent between markets immediately across the national border. We also find that price change significantly diminished when markets on either side of the border share a common ethnicity. Focusing on markets in Niger only, we find the presence of a within-country ethnic border effect, almost as large as the between-country national border effect. Our results suggest that having a common ethnicity reduces the transaction costs associated with agricultural trade, especially in communications and credit transactions.

Key words: Africa, border effects, agriculture, ethnicity.

JEL: F1, O1, Q1.

1. Introduction

There is general agreement among economists that international trade promotes an efficient allocation of resources, and that factors increasing trade costs may therefore impose a deadweight loss in social welfare. There is also evidence that trade contributes to economic growth (Frankel and Romer 1999, Feyrer 2008). These benefits from trade are an important motivation for research that examines the extent to which national borders hinder trade among industrialized countries, notably by considering the differences in price dispersion between locations on opposite sides of a national border as compared to locations within the same country (Engel and Rogers 1996; Parsley and Wei 2001; Gopinath, Gourinchas, Hsieh and Li 2011).[1]

The allocative and growth effects of international trade may well be greater for low-income countries than for high-income economies. Yet even with this greater motivation for estimating the border effects in low-income countries, there has been limited research on the border effect across and within developing countries, presumably due to the absence of high-frequency price data on narrowly defined goods in spatially distinct locations.[2] By contrast, we construct monthly consumer prices for two agricultural goods — millet and cowpeas — from 70 markets in Niger and northern Nigeria between October 1999 and September 2007. In addition, we have data on a variety of factors that may affect price differences

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[1] The magnitude of these estimates has been questioned by Gorodnichenko and Tesar (2009) who show that differences in underlying price volatility across countries contribute to the estimated border effect.
[2] Research on the border effect in developing countries includes Morshed (2007) and Araujo-Bonjean, Aubert and Egg (2008).

across markets, including rainfall, market size, the geographic location of the market, road distances and fuel prices.

Focusing on agricultural goods that are arguably homogenous, we estimate the *additional* transaction costs incurred when markets are located in different countries, conditional on other factors. In the absence of formal trade barriers or natural impediments between these two countries, we interpret these additional costs as border effects, similar to the interpretation given by Gopinath, Gourinchas, Hsieh and Li (2011, henceforth GGHL).

In line with the macroeconomics literature on border effects in industrialized countries, we first examine the cross-border price differences of market pairs between countries, as compared with the same differences within each country (Engel and Rogers 1996). Controlling for transport costs and local market conditions, we find that price differences are relatively more responsive within countries rather than between countries. The regression-based estimate of the border effect is 2 to 3 percent for both commodities. This is quite modest as compared to results found for industrialized countries.

Recognizing the omitted variables bias associated with this market-pair approach, we build upon the single market analysis employed by GGHL to evaluate the change in the price of a product in one market that is supposedly relocated just across the border. Using this single market approach, we find a price change at the border of 17 to 26 percent for millet, and a slightly larger effect for cowpeas.

A novel feature of our study is the examination of the role of ethnicity on trade, both across international borders and across de facto spatial separation of ethnic groups within Niger. To our knowledge, this is the first study of the effects of ethnic diversity on domestic and cross-border trade.[3] Our study relies on two facts to measure these effects. First, the Niger-Nigeria border, created in the wake of the 1884–85 Berlin Conference, was drawn to divide an ethnically homogeneous region, similar to other countries in sub-Saharan Africa (Awiwaju 1985). Second, ethnic groups within Niger cluster in distinct geographic regions, creating a *de facto* separation among ethnic groups — an "ethnic border" — within the country.

We use these facts to analyze the effect of common ethnicity on mitigating differences in prices across the national border. We also examine whether the spatial ethnic separation drives price differences between ethnic regions of Niger in a way similar to the between-country national border. We find that common ethnicity mitigates the costs of cross-border trade: prices are more closely arbitraged between the Hausa regions of Niger and Nigeria than between cross-border markets that do not share a common ethnic composition. We also find that the cost of trade across the internal ethnic border is 17–20 percent, similar to that of trade across the international border.

We provide further but somewhat more speculative evidence on the mechanisms behind the internal border effect by examining traders' characteristics

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[3] Studies of cross-border trade in West Africa have typically been restricted to a few locations and time periods (Azam 2007). Araujo-Bonjean *et al.* (2008) estimate a vector autoregression model using monthly market-level grain price data for markets in Niger, Mali and Burkina Faso and find a statistically significant border effect within the CFA zone.

and behavior close to the ethnic border. While markets on either side of the border engage in cross-border trade and have similar geographic characteristics and institutions, there are significant differences in language, the gender composition of traders and borrowing and lending behavior between the two groups. We posit that these differences have important implications for the role of intra-ethnic social networks in lowering the transaction costs associated with trade. This is consistent with a substantial literature on rural institutions in Africa (Fafchamps 2001) as well as with global evidence documenting the effects of ethno-linguistic fractionalization on outcomes such as growth (Easterly and Levine 1997), corruption (Mauro 1995), contributions to local public goods (Alesina, Baqir and Easterly, 1999) and participation in groups and associations (Alesina and La Ferrara 2000).

The rest of the paper is organized as follows. Section 2 provides the context of our empirical study by discussing some relevant characteristics of the regions, including agricultural trade patterns, the geographic nature of ethnic groupings and the establishment of the international border. Section 3 describes our data, followed by Section 4 discussing the empirical strategy. Section 5 presents the results for the international border effect. Section 6 investigates the role of ethnic diversity in creating internal barriers and the potential microeconomic mechanisms behind this border effect. Section 7 concludes.

2. Trade, Markets, and Ethnicity in Niger and Nigeria

2.1. Historical Roots of Trade between Niger and Nigeria

Niger is one of the poorest countries in the world and the lowest-ranked country on the United Nations' Human Development Index (UNDP 2011). The majority of the population consists of rural subsistence farmers, who depend upon rainfed agriculture as their main source of food and income. As a landlocked country, Niger depends upon trade with its contiguous neighbors, primarily the coastal countries of Benin and Nigeria, but also the landlocked countries of Burkina Faso and Mali.

Niger's trade links with Nigeria have a long and rich history. In the centuries prior to the arrival of the colonial powers, the Hausa ethnic group in modern-day northern Nigeria and Niger was linked to the rest of the continent through a set of long-distance trading routes. One of these was the trans-Saharan trade route connecting Katsina and Kano (Nigeria) to Tripoli (Libya) via Niger. Trade along this route was primarily in slaves, textiles, livestock, grains and salt. A second route was the westward trade in kola nuts between Niger and Nigeria and what is now Ghana (Hashim and Meager 1999).

The 1,500-km border between the French colony of Niger and the British colony of Nigeria was established in the wake of the 1884–85 Berlin Conference. The placement of the border reflected the opposing territorial interests of the French and British colonial administrations; the French government wanted access to Chad across southern Niger, thus moving the border from the northern desert regions to a location within the arable zone further south, while the British

government insisted that the Hausa-Fulani kingdoms of northern Nigeria be kept intact. The border that emerged in 1906 divided the Hausa, Fulani and Kanuri ethnic groups between the two countries.[4] It also created a Niger that included eight primary ethnic groups (Hausa, Songhai/Zarma, Toureg, Fulani, Kanuri, Arab, Toubou and Gourmantche) that were, for the most part, situated in geographically distinct regions (Figure 1).[5]

Few road networks were developed to link Niger and Nigeria during the colonial period, and, as a result, there were relatively few official border crossings by the time of Niger's and Nigeria's independence in 1960. As building more crossing stations was a low priority for the newly independent states, the Niger-Nigeria border was relatively porous post-independence. Both countries have been members of the Economic Community of West African States (ECOWAS) since the mid-1990s. ECOWAS is a regional customs union that allows trade in locally-produced agricultural products (such as millet, sorghum, maize and cowpeas) to be largely free of trade restrictions or governmental regulations. In addition, there are no natural barriers separating the countries.[6]

2.2. Present-Day Agricultural Trade

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[4] The Niger-Nigeria border created a "partitioned culture area" among Hausa and Fulani populations (Asiwaju 1985). At the outset of the international demarcation, inhabitants with farmland straddling the boundary had to choose one colonial side or the other, as French subjects were not supposed to farm on British territory, and vice versa (Miles 2005).

[5] A map of Nigeria in 1957–58 suggests that the geographic location of ethnic groups is similar to the ethnographic maps for 2008.

[6] The Niger River is the principal river of West Africa. The river's source starts in Guinea and empties into the Niger Delta in southern Nigeria. While the river traverses both Niger and Nigeria, it only forms a border between Niger and Benin, rather than between Niger and Nigeria.

Trade in agro-pastoral products within and between Niger and northern Nigeria is conducted through a system of traditional markets, each of which is held on a weekly basis. Markets are primarily located in a specific geographic area, such as a village, town or urban center. The density of grain markets within each country varies considerably by geographic region, with inter-market distances for which trade occurs ranging from 10 km to over 1,000 km. The number of traders operating on each market ranges from 24 to 353, with retailers accounting for over 50 percent of all traders.

In this study we focus on two of the most heavily traded goods in these markets, millet and cowpea. Millet is a staple grain in both countries and is produced and consumed in almost all regions, especially those located near the Niger-Nigeria border. Cowpea is produced in most agro-climatic zones of both countries and functions as a cash crop for rural households. Both commodities are heavily traded across the Niger-Nigeria border, although with different trade flows. While cross-border trade occurs throughout the year, millet is more heavily imported into Niger from Nigeria during the pre-harvest period, and cowpea is more heavily exported from Niger to Nigeria immediately after the harvest.

Aker (2010) shows that millet and cowpeas are relatively homogeneous goods in these markets, and that there do not appear to be systematic price premiums either within or across markets based upon size or color of the commodity. Despite attempts to introduce improved varieties over the course of the past decade, the primary type of millet cultivated and sold in southern Niger and northern Nigeria is

pearl millet, *Pennisetum glaucum (*Ndjeunga and Nelson 2005); the primary cowpea

variety is black-eyed cowpea (Lambot 2000).[7] Nevertheless, we attempt to address

potential concerns about the homogeneity of these goods, and the services provided

across markets, in a later section.

Despite the absence of natural or political barriers to trade between the two

countries, there are several potential barriers to trade in agro-pastoral goods at the

international border. One possible source of trade friction arises from currency

exchange costs between the *Communauté Financière Africaine* (CFA) franc of Niger

and the Nigerian Naira.[8] Furthermore, there are often costs due to delays at the

border (waiting for customs papers) or bribes paid to police officers and customs'

officials.[9] Finally, linguistic differences (between the official languages of Niger and

Nigeria, French and English, respectively) could also add to transaction costs if

trade is conducted in these languages.

3. Data

This study constructs five primary and secondary datasets. The first includes

monthly market-level consumer price data for millet and cowpea over an eight-year

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[7] The color of cowpeas in West Africa can be white, black, brown or red (Lambot 2000). In Niger, white and red cowpea varieties are available, but for all of the markets in our sample, only white cowpeas were available.
[8] There was a devaluation of the CFA in 1994, and the CFA is currently pegged to the Euro zone. While both of these events could affect the CFA-Naira exchange rate, they predate our sample period.
[9] Some authors (e.g., Azam 2007) have noted that banditry can be an important cost in the cross-border of certain goods across the border. Banditry and theft does not appear to be an issue in the trade of agricultural products. According to our transporter survey conducted between 2005 and 2007, fewer than 5% of transporters had items stolen during transport over the two-year period, and none of these transporters cited banditry as a primary constraint to trade.

period from October 1999 to September 2007.[10] These data were collected from Niger's Agricultural Market Information System (AMIS) and include prices from 70 markets in Niger and northern Nigeria. The price data from Nigerian markets were also collected by Niger's AMIS, in Naira, and converted into CFA using the CFA/Naira exchange rate of that day. We do not have access to the original price data in Naira nor the daily CFA/Naira exchange rate used for the price conversion.

The second dataset includes information on the latitude and longitude of each market and of the Niger-Nigeria border. These data allow us to calculate the Euclidean distances for market pairs and to control for the distance from each market to the international border.

The third dataset includes monthly data on gasoline prices and the CFA/Naira exchange rate, as well as market-level monthly data on rainfall, the date of mobile phone coverage and road quality. These data were collected from a variety of primary and secondary sources, including the *Direction de la Meteo*, the mobile phone companies, and the Nigerien oil company (SONIDEP).

The fourth dataset is based on a unique survey of traders, transporters and market resource persons collected by one of the authors between 2005 and 2007. These survey data draw on interviews with 400 traders and 205 farmers located in 35 markets and 40 villages across Niger and northern Nigeria. The data contain information about the ethnic composition of traders on each market, which also reveals where ethnic groups are geographically located within a country.

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[10] Price data are the average price in the market on a particular market day for a given weight.

The fifth dataset includes information on the ethnic composition of villages and markets located in the area that divides the Hausa and Zarma ethnic regions of Niger. The dataset includes the latitude and longitude of each village, the date of the village's creation, the current ethnic composition of village residents and the ethnic composition of the village in 1960, the year of Niger's independence.

Table 1 presents summary statistics for both countries between October 1999 and September 2007. Panel A includes data for market pairs located within each country, whereas Panel B includes data for markets located within 250 km of the international border. The average price (CFA/kg) for millet during this time period was higher in Niger, with a statistically significant difference between the two countries (Panel B). This is consistent with the prevailing direction of trade, as Niger is a net importer of millet from Nigeria. By contrast, average cowpea prices are lower in Niger (although the difference is not statistically significant), as Niger exports cowpeas to Nigeria. Markets have slightly more traders in northern Nigeria, and are more likely to be located in an urban center. However, we do not reject the equality of means for most observable characteristics of markets located within 250 km of the international border, with the exception of the prevalence of traders from the Zarma ethnic group.

Figure 1 shows the international border between Niger and northern Nigeria, as well as the location of ethnic groups along the border.[11] As shown in this figure,

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[11] A map of Nigeria in 1957–58 suggests that the geographic location of ethnic groups is similar to the ethnographic maps for 2008.

as well as in Table 1, the Nigerian markets in our sample are only composed of the Hausa and Kanuri ethnic groups.[12]

4. Empirical Strategy

We measure the border effect using two empirical strategies. First, we conduct a market-pair analysis. Similar to analyses conducted in other studies (e.g., GGHL), we aim to answer the question whether price gaps are larger when markets are separated by country than when they are not, conditional on other factors such as the transport cost between the markets.

Second, we consider one market on either side of the border. Our approach closely follows the one used by GGHL. Hereafter, we refer to this as the single-market analysis. In this case we measure the border effect as the change in the price (in logarithm) of a good from selling it in another market immediately across the border, focusing on price levels rather than price gaps. We control for the distance between a market location and the border in order to isolate a change in price *at* the border. This change implies an additional transaction cost imposed solely by the border.

4.1. Market-Pair Analysis

Our regression model for the market-pair analysis is the following:

[12] While members of the Zarma ethnic group live within Nigeria, they constitute a small percentage of the population (0.001 percent) and are geographically focused in the northwest region of the country, near the Benin-Niger border.

(1)
$$\left| \ln \left(\frac{p_{it}}{p_{jt}} \right) \right| = \alpha_0 + \alpha_1 \text{Border}_{ij} + \mathbf{x}'_{it}\alpha_2 + \mathbf{x}'_{jt}\alpha_3 + \mathbf{w}'_{ij}\alpha_4 + \lambda_i + \delta_j + \eta_t + \varepsilon_{ijt},$$

where p_{it} and p_{jt} are the prices (in CFA), at time t in market i and market j,

respectively.[13] "Border$_{ij}$" is a binary variable equal to one if market i and market j

are in different countries (Niger or Nigeria) and zero if both markets are in the

same country; $\mathbf{x}_{it}$ and $\mathbf{x}_{jt}$ are vectors of time-varying variables such as drought and

mobile phone coverage for market i and market j, respectively; $\mathbf{w}_{ij}$ is a vector of

time-invariant observables shared by market i and market j; λ_i and δ_j are fixed

effects for market i and market j, respectively; η_t denotes the monthly time effect;

and ε_{ijt} is the mean-zero disturbance term.

In this model, α_1 represents the average increment in the difference between

log prices — equivalently, the percent change in the magnitude of the *price ratio* —

exclusively attributable to crossing an international border, conditional on market-

level observables and transport costs between markets. However, for a pair of

markets located in different countries and far away from the border, country-level

unobserved heterogeneities can confound the border effect. For our estimation

sample, we therefore consider market pairs no more than 250 kilometers apart, the

mean distance between markets in our sample. To check the robustness of the

results, we also use alternative measures of inter-market distance, namely, those

markets that are no more than 150 kilometers apart. As differences in underlying

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[13] Most market-pair analyses regress a measure of price dispersion between two markets on a binary variable
that equals one if the two markets are separated by a border (Engel and Rogers 1996, Parsley and Wei 2001,
and Ceglowski 2003). GGHL also use a price gap analysis, with the same dependent variable as the one used in
our specification.

price volatility in two countries can bias the estimate of the border effect upward

(Gorodnichenko and Tesar 2009),[14] we also include indicator variables for country-

specific pairs.

4.2. Single-Market Analysis

As suggested above, the effects of unobserved heterogeneity might be

mitigated by restricting the sample to markets within a certain distance of each

other. An alternative approach to controlling for this source of unobserved

heterogeneity is to limit the sample to markets located very close to the border. Our

second approach estimates the effect on a single market price of moving from one

country to another for markets close to the international border. The rationale for

this approach is that markets located close to each other are likely to share, on

average, common observable and unobservable characteristics.[15] This is

particularly relevant in our context, as the Niger-Nigeria border is not formed by

natural features such as rivers, lakes or mountains.

Our regression model for the single-market analysis of the international

border effect is the following (GGHL 2011):

(2) $\qquad \ln p_{it} = \beta_0 + \beta_1 \text{Niger}_i + \beta_2 D_i + \beta_3 \text{Niger}_i \cdot D_i + \mathbf{x}'_{it}\beta_4 + \mathbf{w}'_i\beta_5 + \gamma_t + \varepsilon_{it},$

where p_{it} denotes the price of a good, measured in CFA, sold in market i at time t;

"Niger$_i$" is a binary variable equal to one if market i is in Niger and zero if market i

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[14] Gorodnichenko and Tesar (2009) control for country-specific variability by including indicator variables for country-specific market pairs and find vastly different estimates of the US-Canada border effect.

[15] We also conduct analyses for markets located far away from the border as a robustness check, in which cases the variation in market conditions would most likely account for most variations in the price. We find zero border effects in those cases.

is in Nigeria; D_i denotes the algebraic distance[16] of market i north of the Niger-Nigeria border in kilometers (positive for markets in Niger and negative for markets in Nigeria); $\mathbf{x}_{it}$ is a vector of time-varying variables for market i at time t, which includes access to mobile phone coverage and experiencing drought; $\mathbf{w}_i$ includes the latitude and the longitude of market i;[17] γ_t denotes the monthly time effect; and ε_{it} is the mean zero disturbance term.

In the regression model described by equation (2), the border effect is represented by β_1, which captures the percent change in price implied by relocating a market just across the border.[18] To assess the robustness of our border effect estimates, we consider markets located within different bandwidths (5 km, 20 km, 30 km and 50 km) of the Niger-Nigeria border, as well as higher-order polynomials of the distance variable (D_i).

In their main analysis, GGHL restrict the sample to markets within 500 km of the U.S.-Canada border, although they find very similar results for bandwidths of 100 km or 350 km. Following their approach, we aim to isolate a direct effect of the presence of the border separately from the effect of transaction costs that may vary with the distance of transporting products across the border, as captured by the inclusion of the distance variable. This is particularly important in our study since markets in this area of West Africa have existed for decades, and few of them are

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[16] Here, we use exactly the same term — algebraic distance — as Gopinath *et al.* (2011). The algebraic distance can be positive or negative.

[17] In this way we attempt to control for location-specific time-invariant unobservable characteristics of market *i*.

[18] This approach is equivalent to using a uniform kernel regression (Imbens and Lemieux 2008) for an RD design.

located arbitrarily close to the border. Thus, this limits our ability to employ the standard graphical analysis associated with the RD design.

5. The Niger-Nigeria Border Effect

In this section we present the estimates from our two methods of analysis, with the market-pair results presented in Section 5.1 and the single-market results presented in Section 5.2. While both methods attempt to estimate the price effect of the international border, the market-pair analysis tends to deliver a smaller estimate, for reasons we explain in Section 5.3. We also discuss the robustness of our results in Section 5.4.

5.1. Market-Pair Analysis

The market-pair analyses of the effects of the Niger-Nigeria border on the price ratios for millet (columns 1–5) and cowpeas (columns 6–10) are presented in Table 2. The sample includes market pairs that are within 250 km of each other, implying that no market in the sample is more than 250 km away from the international border.[19]

Columns (1) and (6) present the estimates of the border effect on the price ratio for millet and cowpea, respectively. For both commodities, the difference in the logarithm of prices is equal to about 2 percent and is statistically significant at

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[19] The border effect estimates are robust to an analysis in which we only use market pairs located within 150 km of the Niger-Nigeria border, even though this cuts the sample by almost half. The results are reported in Table A1.

conventional levels. The estimated border effect increases slightly when other covariates are included in the regression, such as the log of transport costs, drought, urban status and mobile phone coverage (columns 2 and 7). We take into account the possibility that these estimated differences reflect differences in price variability within countries, rather than a border effect, by including country fixed effects for market pairs that lie within Niger (columns 3 and 8) or Nigeria (columns 4 and 9). The stability of the border coefficient estimates across these two alternatives (comparing the results in these columns to those in columns 2 and 7, respectively) contrasts starkly with the large differences found by Gorodnichenko and Tesar (2009) in their analysis of price differentials between the United States and Canada.[20]

Columns (5) and (10) represent our first examination of the potential role of ethnicity in inter-market trade. The estimations in these columns augment the specification of columns (2) and (7) by including two additional binary indicators; "same ethnicity," which equals one if a majority of traders located in both markets of a market pair are from the same ethnic group, and the interaction between the "same ethnicity" variable and the "Niger-Nigeria border" variable. In this specification, the effect of the Niger-Nigeria border on the difference (in absolute value terms) between log prices in two markets with different ethnicities is

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[20] Additional evidence of the unimportance of the Gorodnichenko and Tesar (2009) effect for this data set is obtained by plotting the kernel densities of the residuals from the two country-specific regressions, one for Niger and one for Nigeria,

$$\left| \ln \left(\frac{p_{it}}{p_{jt}} \right) \right| = \alpha_0 + \mathbf{x}'_{ijt} \alpha_1 + \eta_t + \lambda_{ij} + \varepsilon_{ijt},$$

for both millet and cowpea. The two panels of Figure A1 plot the kernel densities of the residuals from the regression model above. The kernel densities overlay each other very closely, suggesting that the underlying variation of market-pair price differences are similar in both countries for millet and cowpea.

represented by the coefficient on the "Niger-Nigeria border" variable. The estimated border effect for two markets with a common ethnicity is the sum of the coefficient on the border and the coefficient on the interaction term. The estimated effect of having the same ethnicity on the prices in two markets in the same country is the coefficient on the "same ethnicity" variable.

The results presented in column (5) shows that the price ratio for millet, for a within-country market pair with the same ethnicity, is about one percent lower than the price ratio for a within-country market pair with different ethnicities, conditional on other covariates. The quantitative effect is similar for cowpeas but not statistically significant (column 10). For cross-border markets, having a common ethnicity lowers the price ratio by about 8 percent for millet (column 5), with a statistically significant effect. There is no effect of common ethnicity on cross-border price ratios for cowpea (column 10). Overall, these results suggest that the ethnic composition of a market pair may play a role in determining transaction costs between the two markets, although primarily for millet. We further explore the role of ethnicity in Section 6.

5.2. Single-Market Analysis

The results of the single-market analysis of the effects of the international border are reported in Table 3. A statistically significant coefficient on the binary variable "Niger" indicates a percent change in prices *at* the border between

proximate markets in Niger and Nigeria, conditional on the covariates included in the regression model.

Based on a bandwidth of 5 km, the estimates in Table 3 show that millet prices increase by 22.5 percent when crossing from Nigeria to Niger (column 1). These findings are robust to the inclusion of other covariates that could affect price changes, including monthly time effects, drought and mobile phone coverage (column 2). It is also robust to the inclusion of market fixed effects, as captured by the geographic location of the market (column 3). The results are also robust to alternative bandwidth specifications (20 km, 30 km, 50 km and 200 km). As expected, the estimated magnitude of the border effect decreases and becomes less statistically significant as the bandwidth increases. This is due to the fact that a greater proportion of the price variation of millet can be explained by the differences between Niger and Nigeria rather than by the border *per se*.

The border effect for the price of millet is much smaller between markets of common ethnicity than between markets with different ethnicities. This is shown by the estimates in the last column of each panel, which restrict the sample to markets in the extensive Hausa region that spans the international border. For example, the results in column (4) suggest that prices increase by 7.9 percent when crossing the Niger-Nigeria border within the Hausa region, by comparison with 23.8 percent when comparing cross-border markets that do or do not share the same ethnicity. The impact of ethnicity in mitigating the border effect appears to be even more marked when we increase the bandwidth.

Table 4 repeats this analysis for cowpea prices. The results are consistent with those for millet. Cowpea prices change by about 27 percent at the border (column 1). This magnitude decreases once time-variant covariates and monthly time effects are included (column 2), but remains robust to the inclusion of time-invariant covariates, such as the geographic location of the market (column 3). As in the case of millet, common ethnicity mitigates the border effect (column 4): this effect is estimated at 20.2 percent for cross-border markets, as compared to close to zero (and not statistically significant) for those sharing a common ethnicity.

5.3. Comparing the Two Sets of Estimates

The magnitude of border effect varies significantly according to the estimation strategy, with the market-pair estimates significantly smaller than the single-market analysis. In their study of the U.S.-Canada border effect, GGHL (2011) find a similar pattern: Using a market-pair analysis, they find that the median price gap is 14.6 percent for cross-border pairs, as compared to a "median discontinuous change of 24 percent at the (U.S.-Canada) border" using a single-market analysis (GGHL 2011). Why are the magnitudes of the border effect so different?

There are three primary reasons for different magnitudes of the border effect between the market-pair and single-market analysis. The first relates to the difference in the definition of the dependent variable. While the single-market approach focuses on the price gap between two markets immediately next to the

border (such that the border dummy variable captures the change in price levels of markets that are relocated immediately across the border), the market-pair analyses control for the *distance* between two markets of a pair, either or both of which could be far away from the border. In this specification, the "border effect" is therefore inferred based on the excessive price gap of cross-border pairs relative to the price gap of within-country pairs. As a result, the border effect obtained from market-pair analyses is an average effect of markets located both close to and far away from the border. This average effect could be smaller than the effect for two markets local to the border, as heterogeneities in the market conditions of a market pair could explain a larger portion of the price gap between the two markets as they are situated father away from the border.

Second, while both the market-pair and the single-market analyses estimate the border effect, the underlying population of markets is different. The market-pair analysis is aimed at the average border effect for all markets, controlling for inter-market distances, whereas the single-market analysis is aimed at the local border effect for those markets located immediately next to the border.

A final difference between the two specifications is the interpretation of the border effect. While the coefficient in the single-market model reflects the full unobservable transactions costs associated with crossing the border, the coefficient in the market-pair model reflects the difference in cross-border trade as compared to within-country trade. In other words, the single-market analysis captures absolute cross-border costs, rather than cross-border costs relative to within-country

costs. For this reason, the single-market analysis coefficient will be larger unless the unobservable transactions costs associated with within-country trade are close to zero.

5.4. Robustness of the Estimates

There are several potential threats to the validity of the above findings. First, observable or unobservable determinants of the prices might systematically differ on either side of the border. In particular, the single-market analysis assumes that location relative to the international border is the only determinant of prices that changes discontinuously as one moves across the border. While it is impossible to directly test for such an identification assumption, we can test whether the observed market-level characteristics are similar within a particular bandwidth. Table 5 tests for this more formally by comparing the equality of means for characteristics that could affect price levels on either side of the border. Using both the market panel and trader-level datasets, the observable characteristics are balanced on either side of the Niger-Nigeria border. These results suggest that the border effect is not serving as a proxy for cross-border differences in observable characteristics.

Second, much of the literature in this field has shown that price gaps are highly correlated with exchange rates, and has used exchange rates as an exogenous shock to measure the speed and extent of pass-through. Thus, exchange rate fluctuations could be responsible for the observed border effect. Figure A2

shows the monthly CFA/Naira exchange rate from October 1999 to September 2007. There was a significant appreciation of the CFA (relative to the Naira) between 2000 and 2001, and again between 2002 and 2003. As all of the Nigerian price data were converted into CFA by the AMIS, we do not explicitly control for exchange rate fluctuations in the regression. Therefore, as a robustness check, we estimate the border effect using only data from the 2003 to 2007, the period of time during which there was less exchange rate volatility.[21] The results for the market-pair analyses are reported in Table A2. Overall, the market-pair estimates for the international border effect for millet remain very stable at 3 percent, but the Niger-Nigeria border effect drops to 1 percent for cowpeas, and is no longer statistically significant at conventional levels. In contrast, results (shown in Tables A3 and A4) from the single-market analyses using only the 2003–2007 period are very similar to the ones based on 1999–2007.

An additional threat to the validity of our previous findings is the heterogeneity of the goods and services across cross-border markets. If millet and cowpea are not truly homogeneous products, then the border effect could simply be a proxy for differences in physical attributes. Similarly, traders on either side of the border could provide different services (such as cleaning, bagging or threshing) that are included in the price, which would then appear as a border effect.[22]

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[21] Results for the market-pair analysis using only the 2003–2007 sample are presented in Table A2, and the results based on this period for the single-market analysis are presented in Tables A3 and A4.

[22] For example, Broda, Leibtag and Weinstein (2009) show that prices can vary within cities based upon their location and associated amenities.

While no agricultural commodity can ever be completely homogeneous in terms of size, quality, color and smoothness, Table A5 provides some evidence that the physical attributes of millet, as well as the services provided, are similar on either sides of the international border. Using observations from markets located within 50 km of the Niger-Nigeria border, the results suggest that there are not systematic differences in services, willingness to pay for quality, or the "high-quality" varieties available on these markets. Overall, only 25 percent of traders provide any type of service, including bagging, cleaning, threshing or drying (column 1). Of these, the primary service provided is bagging; there is not a statistically significant difference in these services provided on either side of the border (column 2). 81 percent of traders stated that they were willing to pay for higher quality, with a slightly higher percentage in markets in northern Nigeria as compared with those in Niger (column 3). While traders in Nigeria stated that they were more likely to pay for "quality" as compared with traders in Niger, there is not a statistically significant difference at conventional levels. In addition, the availability of higher-quality millet varieties (*guero* and *haini*) was similar in both Nigerien and Nigerian border markets. Overall, these results suggest no systematic differences in trader's services and product quality across cross-border markets in our sample.

A final threat to the validity of our findings is the absence of trade between cross-border markets. Although we do not have time series data on trade volumes, we provide evidence that traders did in fact engage in trade on either side of the

border from our trader-level data (Table A6). Between 2005 and 2007, 27 percent of

traders in Nigerien markets located near the border bought and sold millet and

cowpea in northern Nigeria, and 55 percent of Nigerian traders bought and sold

agricultural products from Nigerien markets. There is not a statistically significant

difference in the average volume bought and sold by traders operating in Niger and

northern Nigeria during this time period. This suggests that price effects are not

reflecting an absence of trade across the Niger-Nigeria border.

6. The Internal Border Effect

The market-pair and single-market regression results in Section 5 suggest

that a common ethnicity can diminish the international border effect, primarily for

millet. Yet can different ethnic regions create an internal *de facto* border within a

country? Niger offers a good setting for addressing this type of question since there

is a strong geographic separation among ethnic groups. While this is a feature of

many countries within sub-Saharan Africa, we know of no other studies on the

effect of spatial ethnic diversity on intra-national trade.[23]

We begin this section by first defining the ethnic border and its measurement,

before estimating the impact of internal ethnic borders on prices within Niger. We

then offer some potential explanations for the internal ethnic-border effect.

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[23] Michalopoulos (forthcoming) argues that ethnic diversity within a country is driven by differences in land quality, particularly between herders and farmers, as well as state institutions and history (particularly the colonial period). While these factors might be correlated with overall geographic diversity of certain ethnic groups (for example, Touareg pastoralists in the North of Niger and Mali as compared with Hausa and Zarma agriculturalists in the South), they do not appear to explain the West-East differences in ethnic group composition.

6.1. Regression Analysis of the Internal Border

We use both primary and secondary data on the ethnic composition of villages and markets in Niger to identify different ethnic regions and a *de facto* ethnic border. Using the census and trader-level data, we first calculated the ethnic composition of each market, identifying those markets with both low and high degrees of ethnic diversity. Based upon these calculations, we collected additional primary data in October 2011 from villages and markets located in the "high ethnic diversity" region, but located primarily in the Hausa and Zarma zones of Niger.[24] These data include information on the ethnic composition of residents within each village and market, as well as the ethnic composition in 1960 (the time of Nigerien independence). Using these three datasets, we were able to identify the ethnic composition of markets and villages within the geographic area of Niger where the villages move from exclusively Zarma to exclusively Hausa.

The results from this exercise are presented in Figure 2. All of the observations are in the Dosso region. The set of villages in the western part of this region, from the western most village of Koikore to the villages of Goubeydé, Tsoungoulma, Batama Beri and Daytagui, are all solely Zarma (with the exception of one mixed village in the north). There is a mixed composition of several villages directly east of this region, and these villages include either Hausa and Zarma

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[24] While there are other internal ethnic borders within Niger, primarily North-South and between the Hausa and Kanuri to the far east, the highest density of markets within our sample occurs within the Hausa-Zarma zone.

residents or Hausa, Zarma and Fulani residents (the villages of Mamadou, Malam Koira, Dogon Dadji and Gaweye). Further east one sees a switch to solely Hausa villages.

Using these data, we were able to identify the internal ethnic border related to these two groups: namely, a set of markets with a high degree of ethnic diversity that also separate two geographic regions with a low degree of ethnic diversity. Defining those markets and villages with diverse ethnic composition as the "ethnic border," we calculated the Euclidean distance between the markets in our sample and this border.[25]

Table 6 tests for the equality of means of observable characteristics between markets located on either side of the Hausa-Zarma border. We do not find a statistically significant difference for either urban status or the prevalence of drought, two of the most important determinants of supply and demand in these markets. Nor is there a difference in a market's elevation, a characteristic used by Michalopoulos (forthcoming) as a determinant of ethnic diversity. However, markets in the Zarma region were more likely to have had mobile phone coverage between 1999 and 2007, as mobile phone coverage arrived relatively earlier in the Zarma markets. We therefore control for mobile phone coverage in our regression analysis.

We estimate the ethnic border effect with the single-market regression:

(3) $\ln p_{it} = \gamma_0 + \gamma_1 \text{Zarma}_i + \gamma_2 D_i + \gamma_3 \text{Zarma}_i \cdot D_i + \mathbf{x}'_{it}\gamma_4 + \mathbf{w}'_i\gamma_5 + \delta_t + \varepsilon_{it},$

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[25] While we rely on all of the villages in the sub-region to locate the Hausa-Zarma border, our empirical analysis is restricted to the subset for which we have price data.

where p_{it} denotes the price of an agricultural good in CFA sold in market i at time t; "Zarma$_i$" is a binary variable, which equals one if market i is in the Zarma region of Dosso and zero if it is in Hausa region; D_i denotes the algebraic distance of market i to the Hausa-Zarma border in kilometers (positive for Zarma markets and negative for Hausa markets); x_{it} is a vector of time-varying variables for market i at time t, which includes having mobile phone coverage and experiencing drought; w_i includes the latitude and the longitude of market i, in an effort to control for location-specific time-invariant unobservable characteristics; δ_t denotes the monthly time effect; and ε_{it} is the mean zero disturbance term. The sample only includes Niger markets. In this model, the border effect is represented by γ_1, which implies a price change by relocating a market just across the ethnic border. While the ethnic "border" is not defined as sharply as the international border, the clustering of markets by ethnicity enables us to locate a set of border villages that divide the Hausa and Zarma regions within one section of Niger.

Table 7 presents the estimates of the Hausa-Zarma border effect for millet. For markets within 20 km and 30 km to the ethnic border (which is practically close according to our empirical setting), we find statistically significant border effects. Using a bandwidth of 20 km, millet prices increase by 21 percent at the internal border (column 1). These results are robust to the inclusion of other covariates that may affect price changes, as well as controlling for monthly time effects and the market's latitude and the longitude (column 2). They are also robust to comparing

markets located within a 30-km radius on either side of the border, suggesting that prices change by 26 percent at the internal border.

Because there are few markets located very close to the ethnic border, using markets located within 20 km or 30 km to the border could potentially bias the border effect estimation. For markets located father away from the border, the border indicator can become an indicator variable for ethnicity, representing an ethnic difference (such as difference in preferences) rather than the difference in transaction costs incurred at the ethnic border. For example, if millet is preferred and highly demanded in Zarma markets, but not in Hausa markets, then we would expect to find a significant price difference between these two regions even with a very wide bandwidth, thereby representing an ethnic difference. In contrast, if there is no ethnic difference, but additional transaction costs incurred for cross-border trade, then we would expect the price difference to be present near the border, but absent for markets located far away from the border.

To implement this check, we select markets located more than 50 or 100 km away from the ethnic border and re-estimate equation (3). If we find a statistically significant border effect with these samples, then our previous results in columns (1)–(4) could have alternative explanations. Our results in columns (5)–(8) confirm no border effect. Furthermore, we re-estimate equation (3) using the full sample, and still find no effect. Overall, our check suggests that the choice of markets near the ethnic border (that is, the bandwidth) is not a source of bias, and the difference

in ethnicity seems to create a substantial transaction cost for millet precisely at the ethnic border.

We repeat the same analyses for cowpea and report the results in Table 8.[26] The results are similar to the ones for millet. Cowpea prices change by 22 percent at the internal border (column 1), a result that is robust to the inclusion of both time-invariant and time-variant covariates and monthly time effects (column 2). The effect is slightly higher for markets located within 30 km of the internal border (columns 3 and 4), but there is no effect for markets located at least 50 km or 100 km away from the ethnic border, or for the full sample.

As the ethnic border is not as clearly defined as an international border, this could lead to measurement errors in our "distance-to-border" variable. Nonetheless, two characteristics of the estimates presented in Tables 7 and 8 suggest that those measurement errors could be minor. First, our estimates are similar with and without controls for the latitude and longitude of each market.[27] Second, our estimates are similar whether we consider markets within 20 km or 30 km of the border.[28]

The magnitude of the price effects of the internal ethnic border and the international border are quite similar. Thus, the border costs between the Hausa and Zarma regions of Niger appear to be at least as great as those imposed by the

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[26] In the case of markets within 20 and 30 km in Table 8, we were unable to include the "distance" or its interaction with the "border" variable in the cowpea regressions due to numerical problems incurred in estimation, likely due to rather limited variation in this "distance" variable for cowpea markets.

[27] For markets located on the same latitude or longitude, the measurement errors, likely to be common to these markets, would be differenced out with the latitude and longitude fixed effects.

[28] The small number of markets that are very close to the border precludes us from presenting a graphical analysis of the discontinuity effect that is typically presented in studies of this type.

international border with Nigeria. The deadweight losses in foregone internal trade may correspondingly be of a similar order of magnitude.

6.2. Potential Mechanisms of the Ethnic Border Effect

Our most striking result is that markets located close to the ethnic border have large price discontinuities for homogeneous goods. Yet Table 6 suggests that systematic differences in observed covariates for markets located close to this border are not driving the price change at the border. What could then account for the ethnic border effect? This section presents results from the trader-level survey data collected during a subset of our sample period. The data suggest that ethnicity is correlated with differences in language, the gender composition of traders, and lending and borrowing behavior, each of which could create additional transaction costs to trade across the ethnic border.

Language

If traders are unwilling or unable to communicate with each other, either due to linguistic or socio-cultural factors, then language differences could potentially increase the transaction costs associated with inter-ethnic trade. The statistics in Table 9 (Panel B) show notable linguistic differences across the Hausa and Zarma markets located close to the internal border; while all traders speak Hausa in Hausa markets, fewer than 20 percent speak Hausa in Zarma markets (column 2). These differences are more pronounced for the Zarma language, as fewer than 1 percent of traders in Hausa villages speak Zarma. These effects are partially correlated with gender; once controlling for gender, the linguistic gap between the

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two markets decreases. Even though price and quantity negotiations between Hausa and Zarma traders can be conducted with a very low level of linguistic proficiency, this still introduces a cost not present in intra-ethnic trade. But perhaps more importantly, language differences might be correlated with difficulties in restraining cheating with respect to quantity or quality, partly (but not solely) because language differences reflect an absence of long-run personal relationships and a lack of informal community-level enforcement mechanisms. Language differences may therefore increase transactions costs indirectly, by weakening these second-best enforcement mechanisms.

Gender

While women represent only 6 percent of traders on Hausa markets, they comprise over 25 percent of traders in Zarma markets.[29] This pattern conforms with broader socio-cultural differences in the role of women between the two groups. According to anthropological studies, Zarma women are able to travel outside of their villages to visit family or engage in trade, a custom that is much less frequent among Hausa women (Coles and Mack 1991). While we do not have direct evidence on the degree — if any — of within-village market segmentation by gender, any barrier to transactions *between* men and women will generate a difference in

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[29] This difference in the gender composition of traders becomes more pronounced when moving farther away from the ethnic border. Using the entire sample of Zarma and Hausa markets, only 3 percent of traders are women on Hausa markets, as compared with 31 percent of traders on Zarma markets.

average prices across the ethnic border. This restricts the attractiveness of Zarma

markets for these traders and may reduce the intensity of cross-market arbitrage.[30]

Credit networks

Agricultural trade involves both spatial and temporal arbitrage, as well as a

temporal "dissociation" between delivery and payment (Fafchamps 2000). Both

supplier and client credit play an important role in agricultural markets in Niger.

Since little of this credit is allocated via formal financial institutions, much of this

credit is allocated on the basis of trust (Fafchamps 2000).[31] As in other countries

where firms and traders cannot assess the riskiness of suppliers and clients,

ethnically-based social networks in Niger play an important role in circulating

information about credit histories and risk preferences to potential trading

partners.

Traders often require financial services to pre-finance their purchases or to

respond to fluctuating supply and demand. Table 9 shows that 40 percent of

traders obtained loans for their business operations, primarily from fellow traders

(50 percent) or friends and family members (22 percent) (Panel D). Whereas 60

percent of traders received supplier credit (with an implicit monthly interest rate of

7 percent), over 75 percent sold on credit (for a longer duration and higher interest

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[30] Even if Hausa traders are less willing to trade with women in Zarma markets, they could potentially conduct the trade with a male trader on the Zarma market, who could then purchase from the female trader. This scenario is unlikely, as a majority of female traders are retailers (as opposed to wholesalers or intermediaries). Thus, while female retailers might purchase from male wholesalers, it is unlikely that male wholesalers would purchase from female retailers. This system is somewhat different in the far east of the country, whereby wholesalers purchase from intermediaries during certain periods of the year. However, these intermediaries are exclusively male. The intermediated transaction described above would therefore be subject to additional transaction costs.

[31] Fafchamps (2000) points out that an ethnic bias in the attribution of credit can be due to both statistical discrimination and network effects.

rate). The prevalence of the use of credit was similar in the Zarma and Hausa markets, but the *duration* of supplier and client credit differed significantly; traders in Zarma markets were only able to obtain supplier credit for one week (as compared with 2.5 weeks in Hausa markets), and were only able to offer client credit for 1.5 weeks (as compared with 3 weeks in Hausa markets). Most of these results remain after controlling for gender (column 3). Overall, this suggests that traders in Zarma markets have a shorter duration of borrowing and lending for their commercial operations.

Table 10 analyzes this question in more detail, controlling for factors that could simultaneously be correlated with living in a Zarma market and borrowing and lending behavior. Overall, the patterns are consistent with those in Table 9; once controlling for gender, age, experience and firm size, traders in Zarma markets have a shorter duration of borrowing and lending for their commercial operations.

The difference in the duration of credit Hausa and Zarma markets suggests that credit flows predominate within rather than between ethnic groups. The difference in credit terms, in turn, suggests that this is driven at least in part by barriers to inter-ethnic trade in credit — that is, to transactions costs that are addressed more effectively within ethnic networks than between them. These barriers prevent traders from accessing or granting credit when conducting

commodity transactions in cross-border markets, raising the effective transaction

cost of inter-ethnic trade.[32]

6.3. Alternative Explanations

We also use our trader-level data to address some possible alternative

explanations for our findings. One set of concerns is that colonial policies or

historical political factors could have favored one ethnic group over another, thereby

resulting in different institutions, investments or public services at the village or

market level. Table 9 (Panel A) presents results for market-level institutions

available in Hausa and Zarma markets, as well as potential outcomes correlated

with institutional investment (such as education, experience and firm size). If these

institutions were systematically different on either side of the border, then this

could be a potential explanation for the observed price gap. Half of the Hausa

markets are located near a paved road, and markets impose a market day tax of 75

CFA/kg. There are on average 2.8 police controls in place during the market day,

and an average of 85 agricultural traders (of all types). On average, traders have 15

years of experience and four employees. None of these differences are statistically

significant between the Hausa and Zarma markets, although on average traders on

Zarma markets have less experience (column 2). Controlling for the traders' gender

(column 3), the coefficients are in general smaller in magnitude. Overall, the

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[32] Intra-network credit will generally be an imperfect substitute for credit accessed at the point of transaction: a trader encountering a buying opportunity in a cross-border market, for example, must have secured credit from his "home" network in advance, a costly proposition when the precise nature of this buying opportunity was unknown in advance. The ethnic border within Niger may therefore reflect, at least in part, the prevalence of credit market imperfections and the resulting reliance upon borrowing and lending within ethnic groups.

results in Panel A suggest that different institutional environments do not seem to explain the ethnic border effect.

A final threat to the identification of the internal border effect is the absence of trade between Hausa and Zarma markets. For example, if the absence of long-run relationships across ethnicities translates into higher transaction costs, then this could result in autarky.[33] Table 9 (Panel C) shows the trading behavior of traders on Zarma and Hausa markets. Traders operating on the border markets have similar marketing characteristics: 27 percent of traders are retailers (as compared with intermediaries or wholesalers), search for price information in four markets and have three primary members in their social network. Traders purchase and sell agricultural commodities in 4.15 markets, with relatively fewer markets in the Zarma region. A majority of traders operate within a 50-km radius, although Zarma traders are more likely to trade farther afield and in cross-border markets. These latter differences are statistically significant at the 1 percent level, and remain significant even after controlling for the gender of the trader. Thus, while spatial arbitrage (and cross-border trade) occurs, this is primarily in close proximity and with markets located within the same ethnic region. Overall, these results that the absence of trade between Hausa and Zarma markets is not driving the results.

7. Conclusion

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[33] A more formal model showing the linkages between ethnicity, transaction costs and price gaps is provided in the Appendix.

Using unique high-frequency data on prices of two agricultural goods, our study shows that an international border effect exists between Niger and Nigeria. Furthermore, we find that the additional costs incurred in cross-border trades could be mitigated between markets having similar ethnic composition — the mitigated international border effect suggests that existing regional economic commissions may have been somewhat successful in promoting cross-border trade, even across currency areas or, alternatively, that longstanding trade routes — namely the one that links the Hausa of Northern Nigeria and Niger — continue to influence current-day trade pattern.[34]

Our results suggest that ethnicity plays an important role in trade for agricultural goods: a common ethnicity could facilitate trade between Niger and Nigeria, while distinct ethnicities could increase transaction costs, especially for markets located at the junction of different ethnic regions. Focusing on markets in Niger only, we find that the within-country ethnic border effect could be as large as the between-country national border effect. One implication of this finding is that an ethnic divide could play a central role in the spatial configuration of prices in places where legal enforcement and contracts are lacking, but trust and social sanctions are binding.

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[34] A third hypothesis figures prominently in African studies. Herbst (2000) argues that since the colonial period, the powers that have ruled African capital cities have made mutual bargains not to threaten each other's periphery, and that the international relations regime has acquiesced by conferring de jure status on whomever controls the capital city. Thus, weak states with porous and non-defended borders are a political equilibrium.

Appendix

A Model of Ethnicity, Transaction Costs, and Price Gaps

This appendix shows how a transaction cost can affect the equilibrium price differential between spatially separated markets. This cost may be associated with difficulties trading across ethnic and/or international borders, as discussed in the text. Our model draws on Fafchamps (2001), who analyzed equilibrium prices in a single remote location as a Cournot equilibrium among outside suppliers. Our analysis treats the source and destination locations symmetrically, allowing arbitrageurs to move the commodity in either direction and assuming that they exploit their local market power in both locations.

Assume, then, that traders are spatial arbitrageurs who transport an agricultural commodity (millet) from a market where the price is low to a market where the price is high. There are two spatially separated markets for millet; market X has net export supply curve:

$$P_X = a_X + bX \tag{1}$$

and market M has net import demand curve

$$P_M = a_M - bM. \tag{2}$$

If there is no trade, the autarky prices will prevail ($P_X = a_X$; $P_M = a_M$). We assume that in the current period $a_X < a_M$, so that market X has comparative advantage as an exporter.

There is a set of traders who can move millet from the export market to the import market. To do so, trader i has to purchase an amount z_i of millet from the export market, transport it to the import market, and sell it there. Traders are Cournot competitors who operate by taking the amount of arbitrage trade being done by their competitors as given, and then choosing the optimal prices to set in the two markets and (therefore) the optimal amount to trade. In their price-setting behavior, they operate as a monopsonist with respect to the residual export supply curve in the export market and a monopolist with respect to the residual demand curve in the import market.

If the amount being traded by competitors is fixed at $\tilde{Z}$ (equaling the sum of z_j done by competitors), then the residual net export supply and net import demand curves facing trader i are:

$$P_{Xi} = [a_X + b\tilde{Z}] + bz_i$$

$$\tag{3}$$

$$P_{Mi} = [a_M - b\tilde{Z}] - bz_i$$

The objective of trader i is to maximize revenue net of variable costs. If variable costs are zero (for simplicity; a constant marginal transaction cost can readily be accommodated), total revenue is just

$$R_i = (P_{Mi} - P_{Xi})z_i = (a_M - a_X - 2b\tilde{Z} - 2bz_i)z_i. \tag{4}$$

The first-order condition for the choice of z_i is $\partial R_i / \partial z_i = 0$, or

$$(a_M - a_X - 2b\tilde{Z}) = 4bz_i, \tag{5}$$

which yields an optimum because $\partial^2 R_i / \partial z_i^2 = -4b < 0$. If we impose symmetry across traders, then $\tilde{Z} = (n-1)z_i$ where n is the number of traders engaged in arbitrage. The solution for z_i is then

$$z_i(n) = \frac{a_M - a_X}{2b(n+1)}. \tag{6}$$

Prices in each market are

$$P_X(n) = a_X + \frac{n}{n+1} \cdot \frac{a_M - a_X}{2}$$

$$P_M(n) = a_M - \frac{n}{n+1} \cdot \frac{a_M - a_X}{2}, \tag{7}$$

so the price gap is $P_M - P_X = (a_M - a_X)/(n+1)$. The revenue of each trader in this symmetric equilibrium is

$$R(n) = \frac{1}{2b} \left(\frac{a_M - a_X}{n+1} \right)^2. \tag{8}$$

Suppose now that there is a fixed transaction cost C that any trader has to pay to operate arbitrage between the two villages. This fixed transaction cost could arise from difficulties in trading across locations that differ by ethnicity (and/or by language or gender). Entry of a single trader is profitable as long as $R(0) > C$. If this condition holds, then in the absence of other barriers to entry, entry will occur until $R(n) = C$ (remember, there are no variable costs by assumption). The equilibrium number of traders therefore satisfies

$$n = max \left[\sqrt{\frac{1}{2bC}} (a_M - a_X) - 1, \ 0 \right]. \tag{9}$$

The number of active traders is therefore an increasing function of the autarky price gap (a measure of the gains from trade) and a decreasing function of transaction cost.

The equilibrium price gap between the two markets is

$$P_M - P_X = \frac{a_M - a_X}{n+1} = min\left[\sqrt{2bC}, \ a_M - a_X\right], \tag{10}$$

which is an increasing function of the transaction cost. If the absence of long-run relationships (for example, "networks") in cross-ethnic trade translates into higher transaction costs, then we expect bigger price gaps between markets of different ethnicity than between markets of the same ethnicity.

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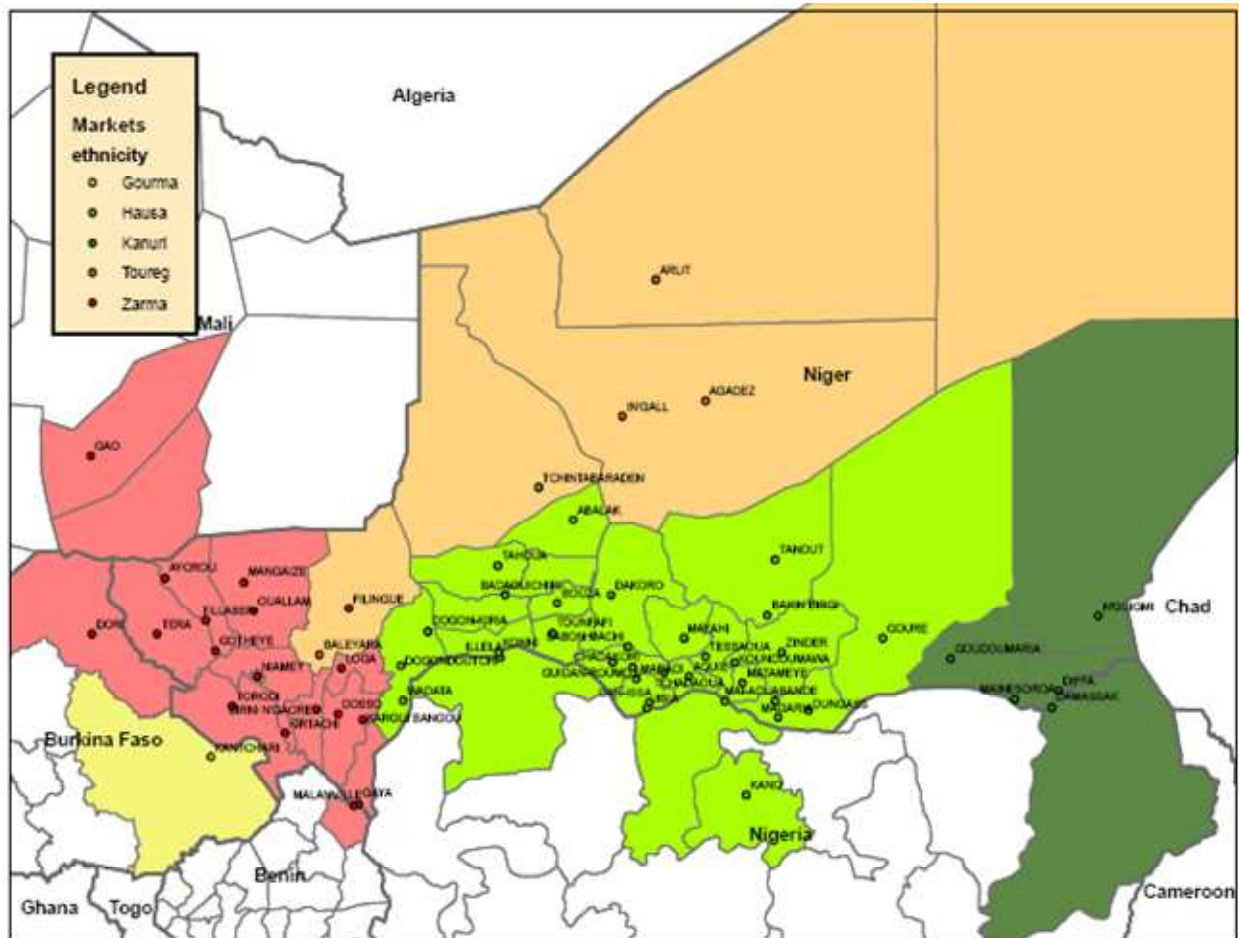
Figure 1. International Borders and Ethnic Groups in Niger and (northern) Nigeria

Notes: A map of the current ethnic and international borders for Benin, Burkina Faso, Mali, Niger and Nigeria, as well as the geographic location of major grain markets in these countries. Each color reflects the geographic location of different ethnic groups within Niger and the surrounding countries. As currently drawn, the ethnic boundaries appear to correspond to administrative (departmental) boundaries, which is not the case; in most cases the ethnic boundary is located within a particular department. Nevertheless, the map shows the general geographic locations of each group. Ethnic boundaries are created from the authors' household and trader-level data collected between 2005 and 2007.
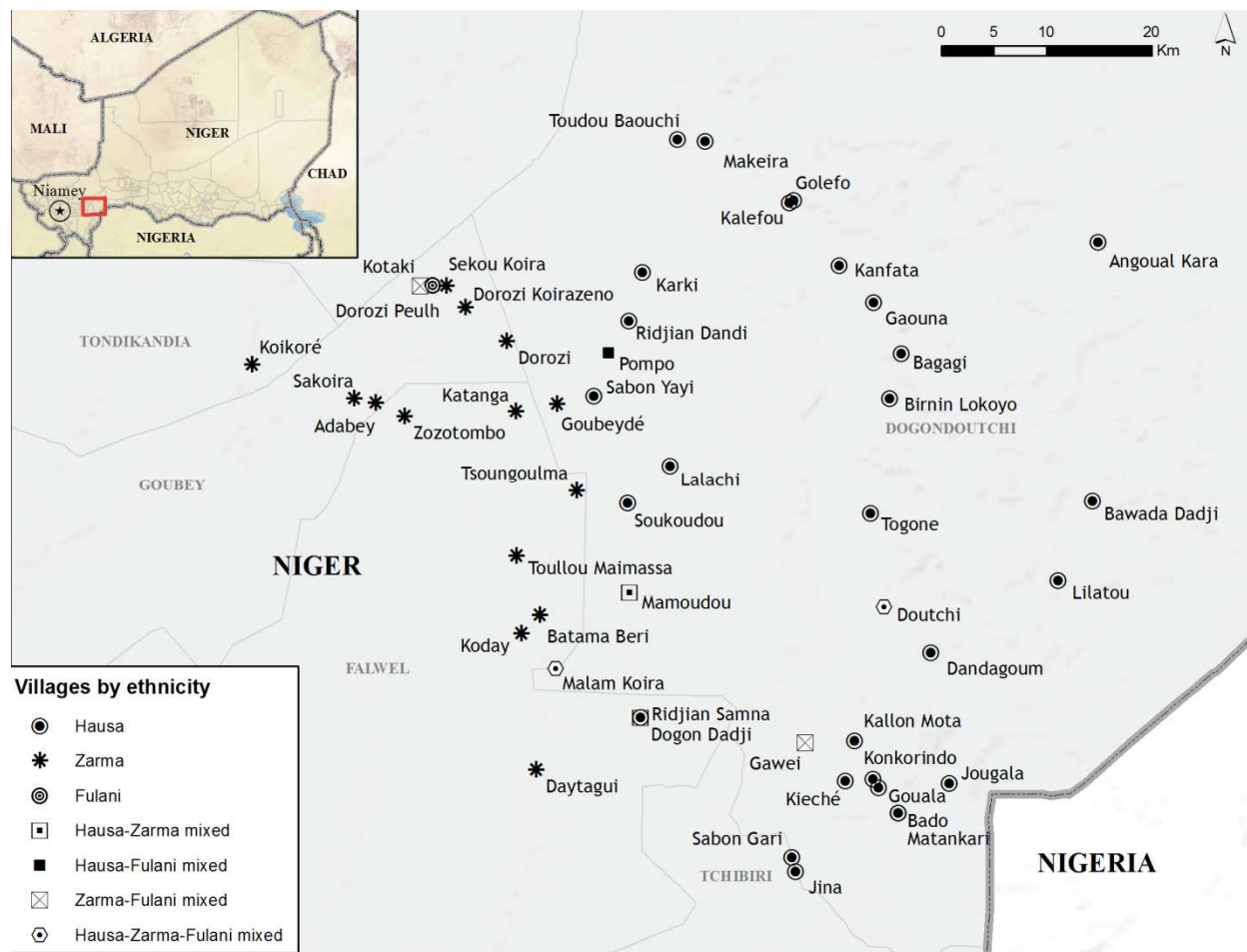
Figure 2. Ethnic Composition of Markets within the Dosso Region

Notes: This map was created using data from a field survey conducted in October 2011. The field survey collected data on the latitude and longitude of each village, the ethnic composition of each village as of October 2011, as well as at the time of Nigerien independence in 1960. The categories included Hausa only, Zarma only, Fulani only, Hausa/Zarma, Hausa/Fulani, Zarma-Fulani, Hausa/Zarma/Fulani. As there were not significant differences in the ethnic composition between 1960 and 2011, the data shown in this map are from October 2011. Those villages with more than two ethnic groups (more specifically, at least a combination of the Hausa/Zarma ethnic group) were used to define the ethnic "border", and distances to this border were defined for all markets in our sample.

Table 1: Summary Statistics and Mean Comparisons by Country (1999–2007)

Panel A: Market pair level data	Market Pairs within		Difference in means
Variables	Niger	Northern Nigeria	(standard error)
	Mean (standard deviation)	Mean (standard deviation)	
Distance between markets (km)	388.00 (207.00)	369.00 (271.00)	18.93 (65.00)
Quality of road between markets	0.37 (0.49)	0.60 (0.52)	-0.22* (0.16)
Mobile phone coverage (2007)	0.23 (0.42)	0.32 (0.47)	-0.09 (0.08)
Transport costs between markets (CFA/kg)	12.76 (6.72)	12.19 (6.67)	0.57 (1.98)

Panel B. Market level data	Markets within		Difference in means
Variables	Southern Niger	Northern Nigeria	(standard error)
	Mean (standard deviation)	Mean (standard deviation)	
Millet price (CFA/kg)	124.00 (33.00)	112.00 (31.00)	11.60*** (3.30)
Cowpea price (CFA/kg)	173.00 (56.00)	176.00 (56.00)	-3.21 (8.20)
Ethnic composition of traders			
Hausa	0.58 (0.51)	0.80 (0.45)	-0.21 (0.21)
Zarma	0.29 (0.46)	0	0.29*** (0.10)
Kanuri	0.08 (0.27)	0.20 (0.45)	-0.12 (0.19)
Quality of road to market	0.71 (0.46)	0.80 (0.44)	-0.09 (0.21)
Market size (number of traders)	105.08 (90.00)	176.75 (149.00)	-71.66 (69.00)
Mobile phone coverage (1999–2007)	0.36 (0.48)	0.45 (0.50)	-0.08 (0.11)
Drought between 1999 and 2007	0.03 (0.16)	0.03 (0.16)	0.00 (0.01)
Urban center (at least 35,000 people)	0.33 (0.49)	0.80 (0.45)	0.46** (0.21)

Notes: Data are from the Niger trader survey and secondary sources collected by one of the authors. Prices are deflated by the Nigerien Consumer Price Index. In Panel A, market pairs within Niger (or Northern Nigeria) are the ones where both markets are located in Niger (or Nigeria). In Panel B, markets in Southern Niger or Northern Nigeria are located within 250 km of the Niger-Nigeria border. In Panel A standard errors are robust to market-pair level clustering; in Panel B standard errors are robust to market level clustering. * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

Table 2: Estimates of the Niger-Nigeria Border Effect Based on Market Pair Regressions

	Millet					Cowpea				
Dependent variable: $|\ln (P_{it}/P_{jt})|$	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Niger-Nigeria border	0.021***	0.024***	0.024***	0.032***	0.104***	0.018**	0.023***	0.023***	0.047***	-0.004
	(0.003)	(0.003)	(0.003)	(0.007)	(0.012)	(0.009)	(0.008)	(0.008)	(0.009)	(0.056)
Niger market			0.008					0.024**		
			(0.009)					(0.012)		
Nigeria market				-0.008					-0.024**	
				(0.009)					(0.012)	
ln (transport costs)		0.052***	0.052***	0.052***	0.048***		0.068***	0.069***	0.069***	0.067***
		(0.003)	(0.003)	(0.003)	(0.003)		(0.004)	(0.004)	(0.004)	(0.010)
Same ethnicity					-0.010**					-0.024
					(0.005)					(0.022)
Same ethnicity × Niger-Nigeria border					-0.085***					0.030
					(0.011)					(0.057)
Constant	0.161***	0.092***	0.084***	0.092***	0.107***	0.276***	0.188***	0.164***	0.188***	0.206***
	(0.000)	(0.003)	(0.008)	(0.003)	(0.006)	(0.000)	(0.006)	(0.012)	(0.006)	(0.008)
Other covariates	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Monthly time effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample size	23,760	23,760	23,760	23,760	23,760	22,689	22,689	22,689	22,689	22,689

Notes: Data are from the Niger trader survey and secondary sources collected by one of the authors. The estimation samples include market pairs located within 250 km of the Niger-Nigeria border. The "Niger-Nigeria border" variable equals one for market pairs located in different countries, and zero otherwise. The "Niger market" variable equals one for market pairs located only in Niger, and zero otherwise. The "Nigeria market" variable equals one for market pairs located only in Nigeria, and zero otherwise. The "same-ethnicity" variable equals one if both markets in a pair have the same ethnic composition, and zero otherwise. Other covariates include the presence of drought, mobile phone coverage and urban status. Standard errors clustered by month are reported in parentheses. * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

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Table 3: Estimates of the Niger–Nigeria Border Effect on Millet Price Based on Single Market Regressions

Dependent variable: Log of millet price	Within 5 km of the Niger-Nigeria Border				Within 20 km of the Niger-Nigeria Border				Within 30 km of the Niger-Nigeria Border			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Niger (1/0)	0.225***	0.173*	0.238***	0.079**	0.219***	0.169**	0.230***	0.005	0.188***	0.178**	0.263***	-0.066
	(0.035)	(0.076)	(0.041)	(0.030)	(0.038)	(0.073)	(0.051)	(0.023)	(0.043)	(0.076)	(0.070)	(0.067)
Constant	4.729***	4.755***	3.569***	1.671***	4.752***	4.774***	3.577***	0.860***	4.738***	4.741***	2.836**	1.776*
	(0.007)	(0.014)	(0.760)	(0.176)	(0.019)	(0.016)	(0.952)	(0.124)	(0.012)	(0.016)	(0.933)	(0.843)
Distance to the Border	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Niger × Distance	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance squared	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance cubic	No	No	No	No	No	No	No	No	No	No	No	No
Sample size	625	625	625	472	682	682	682	529	867	867	867	618

	Within 50 km of the Niger-Nigeria Border				Within 200 km of the Niger-Nigeria Border				Full Sample			
	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
Niger (1/0)	0.168***	0.155**	0.183**	-0.150	0.106*	0.104*	0.103	0.054	0.089*	0.085*	0.068	0.072
	(0.048)	(0.069)	(0.083)	(0.091)	(0.055)	(0.055)	(0.062)	(0.046)	(0.045)	(0.046)	(0.061)	(0.054)
Constant	4.743***	4.745***	3.163***	3.112***	4.762***	4.760***	4.130***	2.157***	4.685***	4.682***	3.935***	2.005***
	(0.014)	(0.016)	(0.632)	(0.801)	(0.029)	(0.027)	(0.514)	(0.633)	(0.011)	(0.015)	(0.499)	(0.681)
Distance to the Border	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Niger × Distance	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance squared	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance cubic	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample size	1,304	1,304	1,304	804	3,496	3,496	3,496	2,081	4,017	4,017	4,017	2,321
Time-variant covariates	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
Time effect (monthly)	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
Time-invariant covariates	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
Markets only in Hausa	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes

Notes: Estimations are based on monthly market-level data. The estimation samples in columns (1) through (20) include markets located within X km of the Niger-Nigeria border (X = 5, 20, 30, 50 and 200). The estimation samples in columns (21) through (24) include all markets. The "Niger" variable is binary: equal to one for a market located in Niger and equal to zero for a market located in Nigeria. The "distance" variable is measured in kilometers and is algebraic, being positive for markets in Niger and negative for markets in Nigeria. Time-variant covariates include having mobile phone coverage (equal to one) or not (equal to zero) and having experienced drought (equal to one) or not (equal to zero). Time-invariant covariates include the latitude and longitude of a market location. Standard errors robust to market level clustering are reported in parentheses. * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

Table 4: Estimates of Niger-Nigeria Border Effect on Cowpea Price Based on Single Market Regressions

Dependent variable: Log of cowpea price	Within 5 km of the Niger-Nigeria Border				Within 20 km of the Niger-Nigeria Border				Within 30 km of the Niger-Nigeria Border			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Niger (1/0)	0.266***	0.195*	0.202***	-0.064	0.272***	0.214***	0.218***	-0.095	0.305***	0.221***	0.216***	0.111**
	(0.048)	(0.080)	(0.051)	(0.080)	(0.040)	(0.060)	(0.047)	(0.078)	(0.043)	(0.045)	(0.054)	(0.032)
Constant	5.050***	5.104***	3.799***	5.322***	5.060***	5.096***	3.974***	5.329***	5.062***	5.102***	1.844	7.969***
	(0.025)	(0.034)	(0.757)	(0.145)	(0.026)	(0.028)	(0.810)	(0.125)	(0.026)	(0.027)	(1.793)	(1.146)
Distance to the Border	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Niger × Distance	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance squared	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance cubic	No	No	No	No	No	No	No	No	No	No	No	No
Sample size	563	563	563	417	620	620	620	474	806	806	806	564

	Within 50 km of the Niger-Nigeria Border				Within 200 km of the Niger-Nigeria Border				Full Sample			
	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
Niger (1/0)	0.279***	0.268***	0.214**	0.032	0.049	0.042	0.040	-0.071**	0.017	0.011	-0.016	-0.057
	(0.048)	(0.063)	(0.092)	(0.241)	(0.078)	(0.074)	(0.079)	(0.030)	(0.070)	(0.068)	(0.069)	(0.034)
Constant	5.070***	5.086***	4.921***	3.610	5.172***	5.174***	4.854***	3.374***	5.120***	5.123***	4.498***	2.887***
	(0.028)	(0.027)	(0.949)	(2.113)	(0.058)	(0.047)	(0.674)	(0.646)	(0.038)	(0.026)	(0.639)	(0.742)
Distance to the Border	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Niger × Distance	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance squared	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance cubic	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample size	1,247	1,247	1,247	744	3,345	3,345	3,345	1,963	3,862	3,862	3,862	2,203
Time-variant covariates	No	No	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Time effect (monthly)	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Time-invariant covariates	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
Markets only in Hausa	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes

Notes: Estimations are based on monthly market-level data. The estimation samples in columns (1) through (20) include markets located within X km of the Niger-Nigeria border (X = 5, 20, 30, 50 and 200). The estimation samples in columns (21) through (24) include all markets. The "Niger" variable is binary: equal to one for a market located in Niger and equal to zero for a market located in Nigeria. The "distance" variable is measured in kilometers and is algebraic, being positive for markets in Niger and negative for markets in Nigeria. Time-variant covariates include having mobile phone coverage (equal to one) or not (equal to zero) and having experienced drought (equal to one) or not (equal to zero). Time-invariant covariates include the latitude and longitude of a market location. Standard errors robust to market level clustering are reported in parentheses. * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

Table 5: Differences in Means for Market-Level Characteristics near the Niger-Nigeria Border

Differences in means for the following variables:	Markets located within X km of the Niger-Nigeria border	
(Niger = 1, Nigeria = 0)	X = 15	X = 50
Panel A: Market level data (1999–2007)		
Having mobile phone coverage (1) or not (0)	0.03	-0.01
	(0.02)	(0.02)
Having experienced drought (1) or not (0)	-0.01	-0.00
	(0.01)	(0.00)
Market located in an urban center (1) or not (0)	-0.25	-0.25
	(0.38)	(0.28)
Paved road (1) or not (0)	0.00	-0.17
	(0.35)	(0.28)
Sample size	1,917	3,834
Panel B: Trader level data (2005–2007)		
Market size (the number of traders)	-12.11	2.85
	(13.31)	(6.54)
Number of police controls	0.09	-0.15
	(0.25)	(0.19)
Sample size	127	232

Notes: Estimations are based on monthly market-level data (Panel A) and trader-level data (Panel B). Mobile phone coverage is measured at market level in each month. The drought variable for a market in a month equals one if 1) the market receives rainfall less than or equal to two standard deviations below its average rainfall level during the rainy season, or 2) if there are 15 consecutive days without rainfall during the rainy season, and zero otherwise. The urban variable for a market equals one if the market is located in an urban center with at least 35,000 people, and zero otherwise. Robust standard errors are reported in parentheses. * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

Table 6: Difference in Means for Market-Level Characteristics near the Hausa-Zarma Border

Differences in means for the following variables:	Markets located within X km of the Hausa-Zarma border	
(Zarma = 1, Hausa = 0)	X = 20	X = 30
Panel A: Market level data (1999–2007)		
Having mobile phone coverage (1) or not (0)	0.31***	0.22***
	(0.06)	(0.04)
Having experienced drought (1) or not (0)	0.00	-0.00
	(0.02)	(0.02)
Market located in an urban center (1) or not (0)	0.50	0.17
	(0.61)	(0.58)
Sample size	288	480
Panel B: Trader level data (October 2011)		
Elevation (in meters)	-0.02	0.00
	(0.02)	(0.00)
Sample size	15	30

Notes: Estimations are based on monthly market-level data (Panel A) and trader-level data (Panel B) collected from the October 2011 field survey on ethnic composition. including monthly time effects. Mobile phone coverage is measured at market level in each month. The drought variable for a market in a month equals one if 1) the market receives rainfall less than or equal to two standard deviations below its average rainfall level during the rainy season, or 2) if there are 15 consecutive days without rainfall during the rainy season, and zero otherwise. The urban variable for a market equals one if the market is located in an urban center with at least 35,000 people, and zero otherwise. Robust standard errors are reported in parentheses. * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

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Table 7: Estimates of the Hausa-Zarma Border Effect on Millet Price Based on Single Market Regressions

Dependent variable: Log of millet price	Within 20 km of the Hausa-Zarma border		Within 30 km of the Hausa-Zarma border		At least 50 km away from the Hausa-Zarma border		At least 100 km away from the Hausa-Zarma border		Full Sample	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Zarma (1/0)	0.212***	0.278***	0.173***	0.264***	-0.058	0.073	-0.126	0.070	0.035	0.057
	(0.011)	(0.053)	(0.016)	(0.036)	(0.099)	(0.093)	(0.155)	(0.151)	(0.054)	(0.051)
Constant	4.791***	4.401***	4.808***	4.351***	4.794***	4.142***	4.972***	4.058***	4.817***	4.337***
	(0.011)	(0.406)	(0.008)	(0.068)	(0.147)	(0.516)	(0.333)	(0.633)	(0.040)	(0.375)
Sample size	333	333	420	420	2,695	2,695	2,408	2,408	3,206	3,206
Distance to the Border	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Zarma × Distance	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance squared	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance cubic	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Time effect (monthly)	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Time-variant covariates	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Time-invariant covariates	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes

Notes: Estimations are based on monthly market-level data. All markets are located in Niger. The estimation samples in columns (1) through (4) include markets located within X km of the Hausa-Zarma border (X = 20 and 30). The estimation samples in columns (5) through (8) include markets located at least Y km away from the Hausa-Zarma border (Y = 50 and 100). The estimation samples in columns (9) and (10) include all markets. The "Zarma" variable is binary: equal to one for a market located in Zarma and equal to zero for a market located in Hausa. The "distance" variable is measured in kilometers and is algebraic, being positive for markets in Zarma and negative for markets in Hausa. Time-variant covariates include having mobile phone coverage (equal to one) or not (equal to zero) and having experienced drought (equal to one) or not (equal to zero). Time-invariant covariates include the latitude and longitude of a market location. Standard errors robust to market level clustering are reported in parentheses. * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

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Table 8: Estimates of Hausa-Zarma Border Effect on Cowpea Price Based on Single Market Regressions

Dependent variable: Log of cowpea price	Within 20 km of the Hausa-Zarma border		Within 30 km of the Hausa-Zarma border		At least 50 km away from the Hausa-Zarma border		At least 100 km away from the Hausa-Zarma border		Full Sample	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Zarma (1/0)	0.215**	0.222***	0.256***	0.295***	0.072	-0.137	0.151	-0.008	0.064	-0.071
	(0.037)	(0.004)	(0.029)	(0.003)	(0.095)	(0.168)	(0.136)	(0.192)	(0.063)	(0.088)
Constant	4.966***	5.721***	5.047***	3.184***	4.909***	6.773***	4.777***	6.032***	4.981***	6.105***
	(0.000)	(0.195)	(0.015)	(0.290)	(0.155)	(0.973)	(0.310)	(1.019)	(0.035)	(0.618)
Sample size	267	267	355	355	2,649	2,649	2,362	2,362	3,094	3,094
Distance to the Border	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Zarma × Distance	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Distance squared	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Distance cubic	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Time effect (monthly)	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Time-variant covariates	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Time-invariant covariates	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes

Notes: Estimations are based on monthly market-level data. All markets are located in Niger. The estimation samples in columns (1) through (4) include markets located within X km of the Hausa-Zarma border (X = 20 and 30). The estimation samples in columns (5) through (8) include markets located at least Y km away from the Hausa-Zarma border (Y = 50 and 100). The estimation samples in columns (9) and (10) include all markets. The "Zarma" variable is binary: equal to one for a market located in Zarma and equal to zero for a market located in Hausa. The "distance" variable is measured in kilometers and is algebraic, being positive for markets in Zarma and negative for markets in Hausa. Time-variant covariates include having mobile phone coverage (equal to one) or not (equal to zero) and having experienced drought (equal to one) or not (equal to zero). Time-invariant covariates include the latitude and longitude of a market location. Standard errors robust to market level clustering are reported in parentheses. * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

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Table 9: Differences in Trader-Level Characteristics between Hausa and Zarma Regions

Variables:	Hausa mean	Unconditional difference in means	Conditional difference in means
	(1)	(2)	(3)
Panel A: Market Institutions			
Road quality (1 = paved, 0 = unpaved)	0.49	0.16	0.05
		(0.46)	(0.43)
Market tax (CFA/kg)	0.75	0.17	0.17
		(0.16)	(0.16)
Number of police controls	2.79	-1.79	-1.75
		(0.91)	(0.85)
Number of traders on market	85.00	1.55	3.02
		(22.36)	(24.66)
Association membership	0.47	-0.14	-0.06
		(0.08)	(0.11)
Years of education	0.18	-0.09	-0.06
		(0.05)	(0.05)
Change original market	0.11	-0.03	-0.01
		(0.05)	(0.05)
Years of experience	15.40	-2.92	-2.09
		(1.61)	-1.74
Number of employees	4.00	-0.56	-0.14
		(0.83)	(1.32)
Panel B: Socio-Demographic Characteristics			
Age	44.13	-0.91	-0.64
		(2.69)	(2.73)
Gender	0.06	0.22***	
		(0.06)	
Speak Hausa language	1	-0.80***	-0.40***
		(0.06)	(0.05)
Panel C: Trading Behavior			
Retailer	0.27	0.04	-0.01
		(0.07)	(0.15)
Number of markets followed	3.77	-0.80	-0.50
		(0.67)	(0.57)
Number of market contacts	3.33	-0.18	-0.34
		(0.50)	(0.51)
Use mobile phone for trading	0.38	0.06	0.05
		(0.07)	(0.10)
Number of purchase and sales markets	4.15	-0.75*	-0.70**
		(0.29)	(0.22)

Trade in markets within a 50-km radius	0.94	-0.11*	-0.12*
		(0.05)	(0.05)
Trade in markets across the Hausa-Zarma border	0.02	0.04	0.03
		(0.02)	(0.02)
Panel D: Borrowing and Lending			
Have financial account	0.24	-0.13	-0.12
		(0.08)	(0.09)
Obtained loan for trading purposes	0.41	-0.02	0.03
		(0.09)	(0.10)
Borrowed from fellow trader	0.50	0.03	0.12
		(0.19)	(0.16)
Borrowed from friend/family	0.22	0.31*	0.32**
		(0.14)	(0.12)
Able to obtain supplier credit	0.70	0.01	0.08
		(0.16)	(0.13)
Purchased on credit since last harvest	0.60	0.11	0.20*
		(0.14)	(0.10)
Duration of supplier credit (days)	17.42	-10.51*	-9.53
		(4.90)	(4.89)
Implicit monthly interest rate (%)	0.07	0.09	0.12
		(0.08)	(0.12)
Willing to provide client credit	0.85	0.05	0.06
		(0.09)	(0.10)
Sold on credit since last harvest	0.75	0.08	0.10*
		(0.06)	(0.05)
Duration of client credit (days)	24.00	-14.60	-14.57*
		(7.70)	(7.07)
Implicit monthly interest rate (%)	0.17	-0.05	-0.03
		(0.12)	(0.12)

Notes: Data are from the Niger trader survey and secondary sources collected by one of the authors between 2005 and 2007. There are 400 traders across 35 markets. Column (1) shows the mean in Hausa markets located within 50 km of the Hausa-Zarma "border." Column (2) shows the unconditional difference in means between Hausa and Zarma border markets. Column (3) shows the conditional difference in means between Hausa and Zarma border markets, controlling for the gender of the trader. Standard errors robust to market level clustering are reported in parentheses. * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

Table 10: Differences in Trader-Level Borrowing and Lending between Hausa and Zarma Regions

| Variables	Obtained loan for trade	Borrowed from fellow trader	Borrowed from friend	Able to obtain supplier credit	Obtained supplier credit since last harvest	Provide credit to clients	Duration of supplier credit (number of days)	Duration of buyer credit (number of days)	Implicit interest rate supplier credit	Implicit interest rate client credit
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Zarma	0.05	0.16	0.29*	0.05	0.17	0.06	-6.74**	-10.40*	0.04	-0.09
	(0.05)	(0.17)	(0.13)	(0.14)	(0.13)	(0.10)	(1.77)	(4.09)	(0.13)	(0.11)
Gender	-0.27**	-0.14	-0.11	-0.29***	-0.37*	-0.02	-3.41	-1.46	0.05	-0.09
	(0.07)	(0.26)	(0.39)	(0.06)	(0.16)	(0.14)	(3.93)	(7.57)	(0.09)	(0.12)
Age	-0.00	0.01	0.00	0.00	-0.00	0.00	0.36	-0.17	-0.01	-0.01*
	(0.00)	(0.01)	(0.01)	(0.00)	(0.01)	(0.00)	(0.32)	(0.15)	(0.01)	(0.00)
Experience	-0.01	0.01	0.00	-0.01	0.00	0.00	0.40	0.11	-0.00	-0.01
	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.00)	(0.37)	(0.43)	(0.00)	(0.00)
Education	0.19	-0.00	-0.11	0.03	0.00	-0.03	-3.81	16.90	0.00	-0.08
	(0.22)	(0.25)	(0.08)	(0.04)	(0.06)	(0.06)	(4.73)	(14.72)	(0.04)	(0.07)
Retailer	-0.01	-0.09	-0.10	0.11	0.35	-0.10	-11.30	-9.54*	-0.40	-0.22**
	(0.16)	(0.24)	(0.15)	(0.13)	(0.18)	(0.07)	(8.07)	(3.97)	(0.35)	(0.08)
Number of Workers	0.01	0.01	-0.01	0.00	0.00	-0.00	-0.34	-0.63	-0.02	-0.01
	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.48)	(0.50)	(0.02)	(0.01)
Constant	0.57	-0.05	0.16	0.73***	0.47	0.80***	4.07	32.33***	1.01	0.94**
	(0.33)	(0.52)	(0.44)	(0.14)	(0.35)	(0.19)	(12.06)	(6.24)	(0.84)	(0.34)
Sample size	296	132	132	312	272	312	168	232	112	152

Notes: Data are from the Niger trader survey and secondary sources collected by one of the authors between 2005 and 2007. There are 400 traders across 35 markets. Standard errors robust to market level clustering are reported in parentheses. * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

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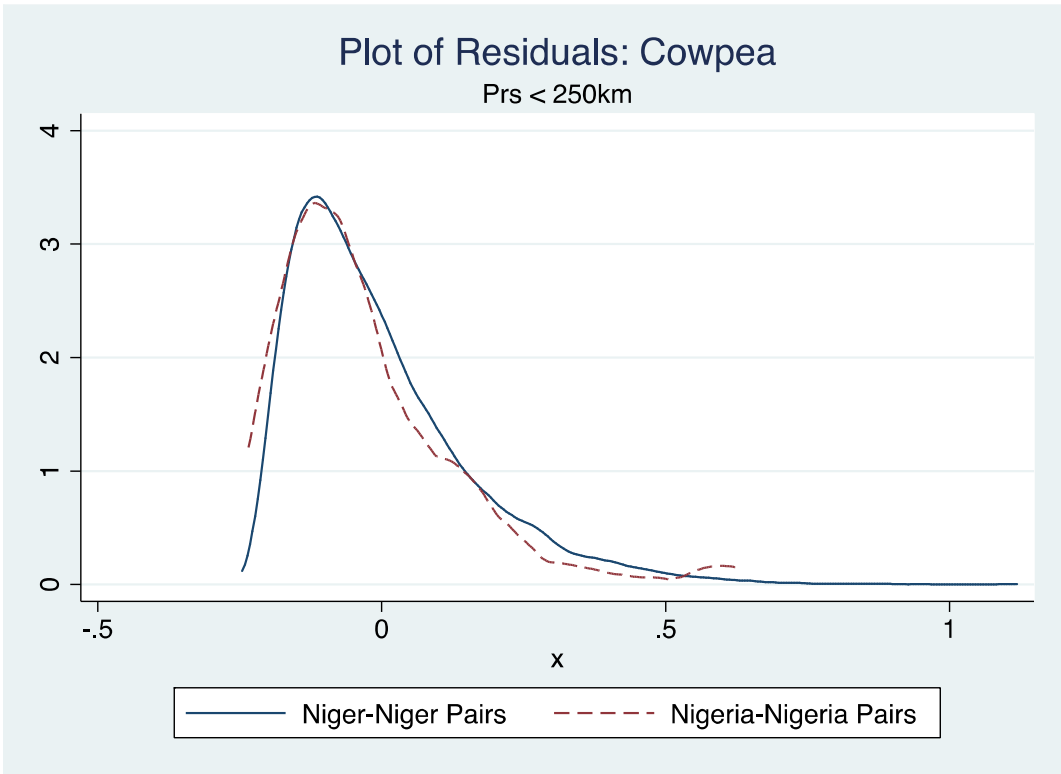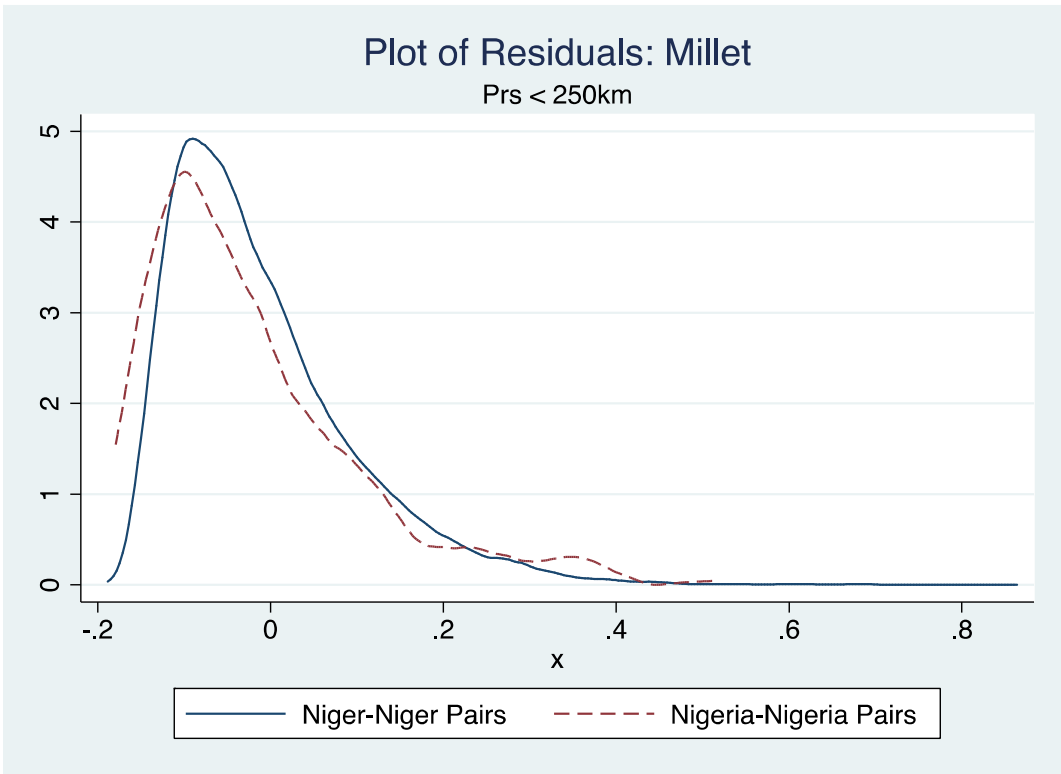
Figure A1. Kernel Density Estimates for Millet and Cowpea Price Residuals

Figure A2. CFA/Naira Exchange Rate between 1999 and 2007

Table A1: Estimates of the Niger-Nigeria Border Effect Based on Market Pair Regressions Using Alternative Distance

	Millet				Cowpea			
Dependent variable: |ln (P_{it}/P_{jt})|	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Niger-Nigeria border	0.02***	0.03***	0.03***	0.01	0.02***	0.03***	0.03***	0.04***
	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Niger market			-0.02*				0.01	
			(0.01)				(0.01)	
Nigeria market				0.02*				-0.01
				(0.01)				(0.01)
ln (transport costs)		0.05***	0.05***	0.05***		0.08***	0.08***	0.08***
		(0.00)	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)
Constant	0.15***	0.10***	0.12***	0.10***	0.22***	0.13***	0.12***	0.13***
	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)
Other covariates	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Monthly time effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample size	12,554	12,554	12,554	12,554	11,922	11,922	11,922	11,922

Notes: Data are from the Niger trader survey and secondary sources collected by one of the authors. The estimation samples include market pairs located within 150 km of the Niger-Nigeria border. The "Niger-Nigeria border" variable equals one for market pairs located in different countries, and zero otherwise. The "Niger market" variable equals one for market pairs located only in Niger, and zero otherwise. The "Nigeria market" variable equals one for market pairs located only in Nigeria, and zero otherwise. Other covariates include the presence of drought, mobile phone coverage and urban status. Standard errors clustered by month are reported in parentheses. * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

Table A2: Estimates of the Niger-Nigeria Border Effect Based on Market Pair Regressions Using the 2003–2007 Period

Dependent variable: |ln (P_{it}/P_{jt})|	Millet				Cowpea			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Niger-Nigeria border	0.03***	0.03***	0.03***	0.03***	0.01	0.01	0.01	0.05***
	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Niger market			-0.01				0.03**	
			(0.01)				(0.01)	
Nigeria market				0.01				-0.03**
				(0.01)				(0.01)
ln (transport costs)		0.06***	0.06***	0.06***		0.07***	0.07***	0.07***
		(0.00)	(0.00)	(0.00)		(0.01)	(0.01)	(0.01)
Constant	0.14***	0.05***	0.06***	0.05***	0.22***	0.13***	0.12***	0.13***
	(0.00)	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)
Other covariates	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Monthly time effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample size	13,581	13,581	13,581	13,581	13,209	13,209	13,209	13,209

Notes: Data are from the Niger trader survey and secondary sources collected by one of the authors. The estimation samples include market pairs located within 250 km of the Niger-Nigeria border. The "Niger-Nigeria border" variable equals one for market pairs located in different countries, and zero otherwise. The "Niger market" variable equals one for market pairs located only in Niger, and zero otherwise. The "Nigeria market" variable equals one for market pairs located only in Nigeria, and zero otherwise. Other covariates include the presence of drought, mobile phone coverage and urban status. Standard errors clustered by month are reported in parentheses. * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

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Table A3: Estimates of the Niger–Nigeria Border Effect on Millet Price Based on Single Market Regressions Using the 2003–2007 Period

Dependent variable: Log of millet price	Within 5 km of the Niger-Nigeria Border				Within 20 km of the Niger-Nigeria Border				Within 30 km of the Niger-Nigeria Border			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Niger (1/0)	0.222***	0.176*	0.270***	0.107***	0.220***	0.178*	0.267***	0.026***	0.168***	0.174*	0.300***	0.024
	(0.034)	(0.084)	(0.036)	(0.011)	(0.034)	(0.082)	(0.044)	(0.007)	(0.047)	(0.083)	(0.047)	(0.048)
Constant	4.725***	4.732***	3.555***	1.803***	4.747***	4.750***	3.525***	0.870***	4.732***	4.730***	2.928***	1.998**
	(0.006)	(0.009)	(0.732)	(0.176)	(0.009)	(0.012)	(0.923)	(0.110)	(0.005)	(0.006)	(0.736)	(0.809)
Distance to the Border	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Niger × Distance	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance squared	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance cubic	No	No	No	No	No	No	No	No	No	No	No	No
Sample size	430	430	430	316	487	487	487	373	601	601	601	430

Dependent variable: Log of millet price	Within 50 km of the Niger-Nigeria Border				Within 200 km of the Niger-Nigeria Border				Full Sample			
	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
Niger (1/0)	0.153***	0.148*	0.201**	-0.077	0.116**	0.109*	0.105	0.065	0.098**	0.088*	0.067	0.081
	(0.049)	(0.075)	(0.083)	(0.102)	(0.055)	(0.055)	(0.064)	(0.049)	(0.046)	(0.048)	(0.064)	(0.057)
Constant	4.736***	4.736***	3.030***	3.761***	4.740***	4.742***	4.054***	2.360***	4.664***	4.665***	3.846***	2.126***
	(0.006)	(0.008)	(0.575)	(0.987)	(0.028)	(0.027)	(0.540)	(0.693)	(0.019)	(0.022)	(0.517)	(0.695)
Distance to the Border	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Niger × Distance	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance squared	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance cubic	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample size	885	885	885	543	2,245	2,245	2,245	1,346	2,580	2,580	2,580	1,511
Time-variant covariates	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Time effect (monthly)	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Time-invariant covariates	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
Markets only in Hausa	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes

Notes: Estimations are based on monthly market-level data from 2003 to 2007. The estimation samples in columns (1) through (20) include markets located within X km of the Niger-Nigeria border (X = 5, 20, 30, 50 and 200). The estimation samples in columns (21) through (24) include all markets. The "Niger" variable is binary: equal to one for a market located in Niger and equal to zero for a market located in Nigeria. The "distance" variable is measured in kilometers and is algebraic, being positive for markets in Niger and negative for markets in Nigeria. Time-variant covariates include having mobile phone coverage (equal to one) or not (equal to zero) and having experienced drought (equal to one) or not (equal to zero). Time-invariant covariates include the latitude and longitude of a market location. Standard errors robust to market level clustering are reported in parentheses. * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

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Table A4: Estimates of the Niger–Nigeria Border Effect on Cowpea Price Based on Single Market Regressions Using the 2003–2007 Period

Dependent variable: Log of cowpea price	Within 5 km of the Niger-Nigeria Border				Within 20 km of the Niger-Nigeria Border				Within 30 km of the Niger-Nigeria Border			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Niger (1/0)	0.179**	0.174*	0.185**	-0.162***	0.189***	0.200**	0.206***	-0.158***	0.206***	0.194***	0.219***	0.222
	(0.051)	(0.077)	(0.057)	(0.018)	(0.037)	(0.059)	(0.052)	(0.020)	(0.043)	(0.043)	(0.055)	(0.126)
Constant	5.059***	5.064***	5.147***	5.277***	5.069***	5.053***	5.185***	5.256***	5.068***	5.059***	2.742	9.977***
	(0.008)	(0.012)	(0.818)	(0.043)	(0.011)	(0.017)	(0.853)	(0.035)	(0.010)	(0.017)	(2.086)	(1.483)
Distance to the Border	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Niger × Distance	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance squared	No	No	No	No	No	No	No	No	No	No	Yes	Yes
Distance cubic	No	No	No	No	No	No	No	No	No	No	No	No
Sample size	375	375	375	268	432	432	432	325	546	546	546	382

	Within 50 km of the Niger-Nigeria Border				Within 200 km of the Niger-Nigeria Border				Full Sample			
	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
Niger (1/0)	0.195***	0.255***	0.186*	0.105	0.047	0.054	0.044	-0.060*	0.019	0.027	-0.008	-0.044
	(0.045)	(0.065)	(0.098)	(0.220)	(0.064)	(0.071)	(0.079)	(0.035)	(0.059)	(0.066)	(0.071)	(0.041)
Constant	5.075***	5.055***	5.220***	5.680**	5.100***	5.081***	4.832***	3.746***	5.059***	5.044***	4.385***	3.112***
	(0.013)	(0.017)	(0.927)	(1.947)	(0.041)	(0.040)	(0.753)	(0.686)	(0.011)	(0.016)	(0.701)	(0.770)
Distance to the Border	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Niger × Distance	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance squared	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance cubic	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample size	829	829	829	494	2,147	2,147	2,147	1,266	2,482	2,482	2,482	1,431
Time-variant covariates	No	Yes	Yes	Yes	No	No	Yes	Yes	No	Yes	Yes	Yes
Time effect (monthly)	No	Yes	Yes	Yes	No	No	Yes	Yes	No	Yes	Yes	Yes
Time-invariant covariates	No	No	Yes	Yes	No	No	No	Yes	No	No	Yes	Yes
Markets only in Hausa	No	No	No	Yes	No	No	No	Yes	No	No	No	Yes

Notes: Estimations are based on monthly market-level data from 2003 to 2007. The estimation samples in columns (1) through (20) include markets located within X km of the Niger-Nigeria border (X = 5, 20, 30, 50 and 200). The estimation samples in columns (21) through (24) include all markets. The "Niger" variable is binary: equal to one for a market located in Niger and equal to zero for a market located in Nigeria. The "distance" variable is measured in kilometers and is algebraic, being positive for markets in Niger and negative for markets in Nigeria. Time-variant covariates include having mobile phone coverage (equal to one) or not (equal to zero) and having experienced drought (equal to one) or not (equal to zero). Time-invariant covariates include the latitude and longitude of a market location. Standard errors robust to market level clustering are reported in parentheses. * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

Table A5: Traders' Services and Quality in Markets within 50 km of the Niger-Nigeria Border

Dependent variable:	Transform product	Bag product	Willing to pay for quality	Haini variety on market	Guero variety on market
	(1)	(2)	(3)	(4)	(5)
Niger (1/0)	0.06	0.02	-0.04	0.01	-0.05
	(0.12)	(0.07)	(0.14)	(0.01)	(0.16)
Constant	0.25	0.75	0.81	0.22	0.86
	(0.07)	(0.00)	(0.13)	(0.00)	(0.14)
Sample size	228	68	224	120	144

Notes: Data are from the Niger trader survey between 2005 and 2007 collected by one of the authors. The "Niger" variable equals one for a market located in Niger, and zero for a market located in Nigeria. Robust standard errors clustered at the market level are reported parentheses. * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

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Table A6: Difference in Trader-Level Characteristics between Niger and northern Nigeria

Trading behavior variables:	Niger		Nigeria		Difference in means	
	Mean	Standard deviation	Mean	Standard deviation	Coefficient	Standard error
Number of markets followed	4.35	3.90	5.29	2.21	-0.93	0.84
Number of market contacts	4.24	3.89	5.00	5.59	-0.76	2.12
Number of purchase and sales markets	4.36	2.85	5.38	1.92	-1.01	0.68
Trade in cross-border markets within a 50-km radius	0.27	0.22	0.55	0.07	-0.28**	0.05
Quantity traded in 2005/2006 (kg)	12,936	59,696	10,025	14,106	-2,911	36,096
Number of police controls	3.80	0.90	4.00	1.00	-0.17	0.69
Market Size (number of traders)	97.30	80.70	176.75	149.00	-79.42	73.02

Notes: Data are from the Niger trader survey and secondary sources collected by one of the authors. The sample includes 415 traders across 37 markets. Robust standard errors are reported in the last column. * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

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