Chapter Title: International and Intranational Market Segmentation and Integration in West Africa

Chapter Author(s): Jenny C. Aker, Michael W. Klein, Stephen A. O'Connell

6
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6.1 Introduction

What muffles, or amplifies, the voice of the Walrasian auctioneer? This question is of more than theoretical interest since a common policy goal is fostering market integration, especially across international borders. The welfare benefits of policies that succeed in integrating cross-border markets are likely to be greater in low-income countries, especially the landlocked countries of sub-Saharan Africa, than in industrial countries. But can government policies like tariff reductions actually increase market integration in the presence of political or social barriers that impede trade? Can regional investments in transport infrastructure help create unified markets in the face of corruption at the border? Put more simply, do borders pose a significant challenge to market integration in sub-Saharan Africa? Or does the Walrasian auctioneer have as clear and loud a voice across countries in sub-Saharan Africa as elsewhere?

Answers to these questions that are based on the volume of trade are mixed. Foroutan and Pritchett (1993) show that the level of trade among African countries is actually higher than that predicted by a gravity model. But other research suggests that intra-African trade is too low, due to internal political tensions and mismanagement of economic policies (Longo and Sekkat 2004). Oyejide, Elbadawi, and Collier (1997) observe that competing national priorities have repeatedly undermined formal attempts at regional integration in Africa, while Azam (2007) stresses the role of informal trade in arbitraging the cross-border price differences created by divergent national trade policies.

In this chapter, we address the impact of political borders on intra-African trade by focusing on prices rather than trade volumes.[1] We consider prices of two staple grains (millet and sorghum) and one cash crop (cowpeas) in markets in Niger and Nigeria. We look at price dispersion in cross-border markets as compared to price dispersions in different markets within the same country. This follows the strand of empirical literature that compares price dispersion in spatially separated markets in industrial countries. Results in that literature show that price dispersion is larger when, conditional on distance, two markets are on either side of an international border than when they are in the same country. The seminal contribution by Engel and Rogers (1996), and subsequent work on other industrialized countries, such as the United States and Japan (Parsley and Wei 2001) and EU countries (Crucini, Shintani, and Tsuruga 2010; Crucini, Telmer, and Zachariadis 2005), has consistently found a relatively large border effect.[2]

In this chapter, we show that there is a statistically significant border effect, that is, conditional price dispersion is higher between a market in Niger and Nigeria than between two markets in Niger, or two markets in Nigeria. But this border effect is much lower than what has been found for industrial countries. Furthermore, we also show that the border effect is lower if the cross-border markets share a common ethnic profile, while the effect of ethnicity is to raise conditional price dispersion between two ethnically distinct

1. Border effects in low-income countries have not been the subject of much research, partly due to the lack of high-frequency data on narrowly defined goods. Cross-border comparisons have typically been restricted to a small number of locations and over a limited time period. Daubrée (1995) compares the prices of a range of consumer goods between Niamey (the capital of Niger), Maradi (Niger), and Kano (Nigeria), and finds tighter comovements between Maradi and Kano than between Maradi and Niamey. Oyejide, Ogunkola, and Bankole et al. (2005) compare prices for markets within Nigeria with those in between the capitals of Niger, Togo, and Benin, and finds suggestive evidence of a border effect. Araujo-Bonjean, Aubert, and Egg (2008), use a vector autoregression model to estimate integration of millet prices between countries within the CFA zone (Niger, Mali, and Burkina Faso), and find a statistically significant border effect.

2. As discussed in more detail below, Gorodnichenko and Tesar (2009) have shown that these estimates overstate the border effect when they do not take into account underlying differences in price heterogeneity between countries.

markets in Niger. We also show that the presence of mobile phones mitigates the international border effect, which extends the intra-Niger results in Aker (2010) to an international setting.

The results presented here offer a positive message with regard to ongoing efforts to integrate West African economies. These countries have attempted to foster trade and economic integration through a system of monetary and trade unions such as the West African Economic and Monetary Union (or UEMOA), a customs and monetary union created in 1994 that shares a common currency (the CFA franc) and a common external tariff.[3] The UEMOA is also part of the Economic Community of West African States (ECOWAS), a regional integration initiative created in 2001 among all West African states. More specifically for the two countries studied in this chapter, the National Boundary Commission of Nigeria and a Nigeria–Niger Joint Commission (NNJC) have convened transborder workshops to address issues of cross-border trade. Our results with respect to the effect of the border on price dispersion suggest the positive potential of these efforts.

The rest of the chapter is structured as follows. Section 6.2 provides a context for our analysis by discussing some relevant characteristics of Niger, including the establishment of its international border with Nigeria and the geographic nature of its ethnic divisions. Section 6.3 describes the data we use and provides some preliminary statistics. Section 6.4 present an analysis of the international border effect based on conditional distributions, while section 6.5 analyzes the market-pair data using regressions. Section 6.6 presents the results for internal borders. We offer some conclusions in section 6.7.

6.2   Niger and Its Trade

Niger is a large, sparsely populated, landlocked country in West Africa. The majority of its population consists of rural subsistence farmers who depend upon rain-fed agriculture as their main source of food and income. It is one of the poorest countries in the world. It was ranked last on the United Nations' 2009 Human Development Index.

The primary trading partner of Niger is its southern neighbor, Nigeria, a coastal country that has the largest population in Africa. The 1,500 km border between Niger (a former French colony) and Nigeria (a former British colony) was established by the French and the British in 1906. The border separated the Hausa, Zarma, Fulani, and Kanuri ethnic groups between the two countries. As shown in figure 6.1, the border drawn by the colonial powers also created a Niger that included eight ethnic groups (Hausa, Songhai/

3. The CFA franc was created in 1945, and was devalued in 1948 and 1994 (changing the relative value of the CFA franc to the French franc). The current CFA franc is pegged to the euro.

Market Ethnicity

1 Zarma **2** Hausa **3** Gourma **4** Toureg **5** Kanuri
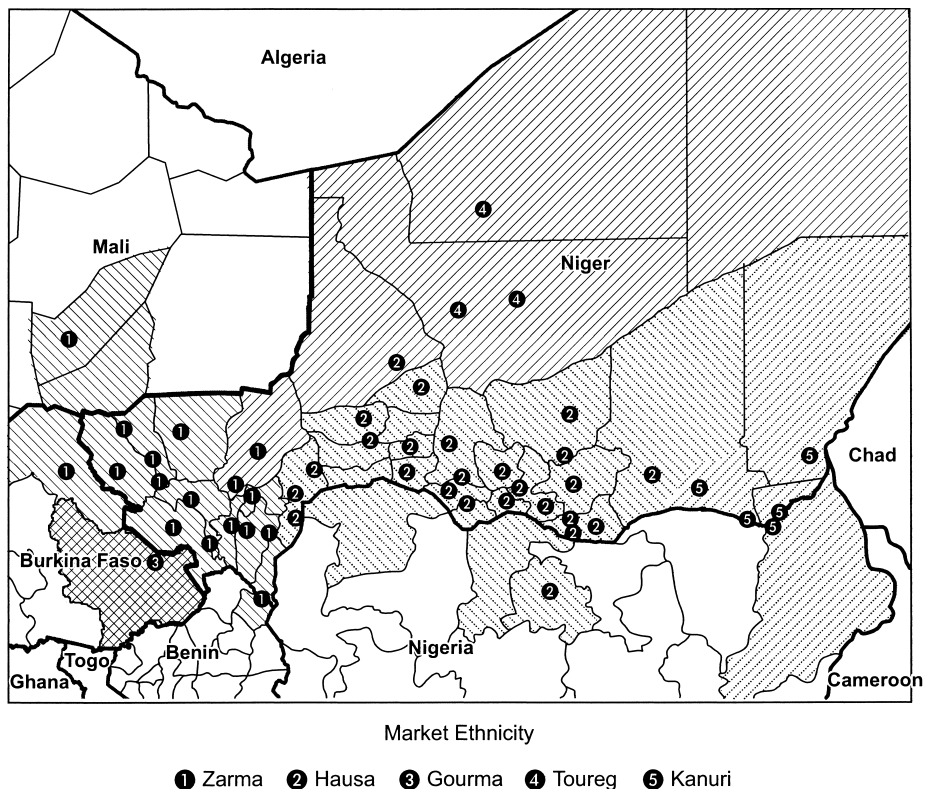
Fig. 6.1   International borders and ethnic groups in Niger and northern Nigeria

Notes: A map of the ethnic and international borders for Benin, Burkina Faso, Mali, Niger, and Nigeria. Created from the authors' household and trader-level data collected between 2005 and 2007, as well as secondary data for markets in Burkina Faso and Mali.

Zarma, Toureg, Fulani, Kanuri, Arab, Toubou, and Gourmantche) which were, for the most part, situated in geographically distinct regions of the country.[4]

The border between Niger and Nigeria was porous and haphazardly patrolled at the time the two countries achieved independence in 1960. Smuggling was a major economic activity.[5] Trade between the two countries was primarily in agropastoral products such as grains, legumes, and livestock (Collins 1976), but "unofficial traders" also brought petroleum and farm-chemical products into Niger (Charlick 1991). There have been

4. A map of Nigeria in 1957–1958 (not shown) also suggests that the geographic location of ethnic groups in Niger and Nigeria seems to be time invariant, as it is similar to the ethnographic maps for 2008.

5. Azam (2007) provides an analytical treatment of the determinants of illegal cross-border trade in the region.

efforts since the early 1970s to harmonize the relationship between the two countries and remove official obstacles to trade. Currently, both countries are members of ECOWAS.

The sample period studied in this chapter is 1999–2007. There were no official trade restrictions or border closings during this time (although there had been border closings in 1983 and 1986, linked to political instability in Nigeria). There are, however, other possible sources of costs of trade between these countries. Nigerien-Nigerian trade could be hampered by costs due to delays, harassment, or banditry. Furthermore, trade between these two countries could be impeded by costs associated with changing currencies between the Communauté Financière Africaine (CFA) franc of Niger and the Nigerian naira. There are also linguistic differences, both between the official languages of Niger and Nigeria (French and English, respectively), and in local languages in different regions of each country.

6.3   Data

The motivation for using prices in different locations to test for the presence of an international border is straightforward; if borders impose costs that undermine trade, then, conditional on distance between markets and other location-specific factors, price differences between markets located in different countries should be larger than those between markets in the same country. Thus our analysis requires both price data and other data used to control for distances between markets and location-specific features in Niger and Nigeria.

The analysis in this chapter uses a data set that draws on both primary and secondary sources in Niger and Nigeria. The price data consist of monthly observations of prices of two grains (millet and sorghum) and a cash crop (cowpeas) over a nine-year period (1999–2007) across forty-eight domestic and cross-border markets.[6] Each of these commodities is produced and consumed in both countries, is heavily traded on an annual basis, and is fairly homogeneous in terms of quality.

Time-series data on gas prices, mobile phone coverage, rainfall, road quality, trade flows, district population levels, mobile phone rollout and coverage, and the official naira-CFA exchange rate were also collected. In addition to these time series, we employ data on the latitude and longitude of each market, the location of the international border, and the road distances between market pairs. These series enable us to calculate the distance to the international and internal border of each market in the data set, as well as the Euclidean distances and actual road distances between market pairs.

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6. Grain prices were collected by Niger's agricultural marketing information system, which converted prices in Nigerian markets into CFA using the CFA/naira exchange rate of that day. We do not have access to the original price data in naira, nor to the daily CFA/naira exchange rates used for the price conversion.

Our analysis also uses a unique panel survey of traders, farmers, transporters, and market resource persons collected in Niger by Aker between 2005 and 2007. The survey data draw on interviews with 415 traders and 205 farmers located in thirty-five markets and forty villages across six geographic regions of Niger, as well as in five Nigerian markets. A census of all grain traders was conducted in each market, in which traders and market-resource persons who participated in the survey provided detailed information about their demographic and socioeconomic background and commercial operations. These data allow us to construct measures of the ethnolinguistic fractionalization (ELF) for each market, village, and region, to identify ethnic "borders," and to measure the number of traders operating in these markets over time.

Table 6.1 presents summary statistics for markets located within a 150 km

Table 6.1   **Comparison of observables by country (Niger-Nigeria)**

Observables	Unconditional mean		Difference in means
	Mean (s. d.)	Mean (s. d.)	Difference (s. e.)
A. Market-pair-level data	**Niger-Niger**	**Nigeria-Nigeria**	
Distance between markets (km)	375.29(207)	369(271)	6.29(65)
Road quality between markets	.37(.49)	.6(.52)	−.22(.16)
Mobile phone coverage (2007)	.89(.32)	.6(.52)	.29*(.16)
Transport costs between markets (CFA/kg)	12.35(6.72)	12.19(6.67)	.16(.22)
B. Market-level data	**Niger**	**Nigeria**	
Millet price level (CFA/kg)	124.33(33)	112.96(31)	11.37***(1.83)
Sorghum price level (CFA/kg)	119(36)	104(34.8)	14.35***(2.04)
Cowpea price level (CFA/kg)	173(56)	176 (56)	−3.21(3.36)
Ethnic composition of traders			
Hausa	.58(.51)	.8(.447)	−.21(.21)
Zarma	.29(.464)	0	.29***(.096)
Kanuri	.08(.27)	.2 (.447)	−.12(.19)
Road quality to market	.71(.46)	.75(.5)	.041(.25)
Market size	105.08(90)	176.75(149)	−71.66(69)
Mobile phone coverage (2007)	.95(.020)	.8(.447)	.158(.19)
Drought between 1999 and 2007	.027(.162)	.025(.156)	.002(.007)
Urban center(> = 35,000)	.35(.49)	0.8 (.45)	.45*(.21)

Notes: Data are from secondary sources and the Niger trader survey collected by Aker. In panel A, "Niger" market pairs are pairs where both markets are located in Niger; "border" market pairs are those pairs where both markets are located in a border country (Nigeria, Benin, Burkina Faso). In panel B, "Niger" markets are those that are located within Niger (150 km from the international border), whereas "border" markets are those markets located outside of Niger (but within 150 km of the border). Huber-White robust standard errors clustered by market-pair month (panel A) and by market month (panel B) are in parentheses. Prices are in CFA francs, deflated by the Nigerien Consumer Price Index. The Kolmogorov-Smirnov test tests for the equality of the distribution functions.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

radius of the Niger-Nigeria border. In general, prices for staple grains (millet and sorghum) are higher in Niger than in Nigeria, with a statistically significant difference between the two. This is consistent with the direction of trade between the two countries, with Niger importing grains from Nigeria. By contrast, cowpea prices are lower in Niger; while the difference is not statistically significant, the point estimate is as expected since Niger primarily exports to Nigeria. We do not reject the equality of means or distributions for most other observable characteristics, with the exception of mobile phone coverage and the prevalence of the Zarma ethnic group. However, the difference in mobile phone coverage as of 2007 is only statistically significant at the 10 percent level. In addition, the Nigerian markets in our sample are only located in the Hausa region of that country, and none are in Nigeria's Zarma region.[7]

6.4   Analysis of Distributions

Our first analysis of the international border effect for markets in Niger and Nigeria uses the data described above to construct kernel distributions for conditional price differences across countries and within countries. We estimate regressions of the form:

$$(1) \qquad \left| \ln\left(p^i_{jt} \, / \, p^i_{kt} \right) \right| = \beta_0 + \beta_1 X_{jkt} + \theta_t + \alpha_{jk} + \varepsilon_{jkt},$$

where p^i_{jt} and p^i_{kt} are the CFA franc prices of good i in markets j and k at time t, deflated by Niger's consumer price index. The regressors in this specification include X_{jkt}, a vector of observable characteristics that affect price dispersion between two markets, including transport costs between markets j and k at time t, a dummy variable that equals 1 if one and only one of the two markets is urban, and another dummy variable that equals 1 if one and only one had a drought at time t. The variable $\theta\alpha_t$ represents time fixed effects. In some specifications market-pair fixed effects, α_{jk}, are also included. Separate regressions are run for market pairs within each country, and also for cross-border pairs. We plot a kernel distribution of the residuals ε_{jkt} from each regression, to examine relative conditional deviations from the Law of One Price.

Figures 6.2A, 6.2B, and 6.2C present the kernel distributions of ε_{jkt} from a regression of equation (1) for millet, sorghum, and cowpeas, respectively, for the entire 1999–2007 period. Each of these three figures includes the kernel distribution for the residuals of a regression using intra-Niger market pairs, a regression using intra-Nigeria market pairs, and a regression using cross-border (Niger-Nigeria) market pairs. Visual inspection of the

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7. While members of the Zarma ethnic group live within Nigeria, they represent a small percentage of the population (approximately 88,000 people, or less than .0007 percent) and are geographically focused in the far northwestern region of the country, on the border with Benin and Niger (the Birin n'Kebbi region).

Fig. 6.2A   Kernel distributions of millet, sorghum, and cowpeas for Niger and Nigeria (1999–2006), ln price difference for intranational and cross-border pairs: Millet pairs < 300 km: Residuals on ln(transport costs), urban, drought

Fig. 6.2B   Kernel distributions of millet, sorghum, and cowpeas for Niger and Nigeria (1999–2006), ln price differences for intranational and cross-border market pairs: Sorghum pairs < 300 km: Residuals on ln(transport costs), urban, drought
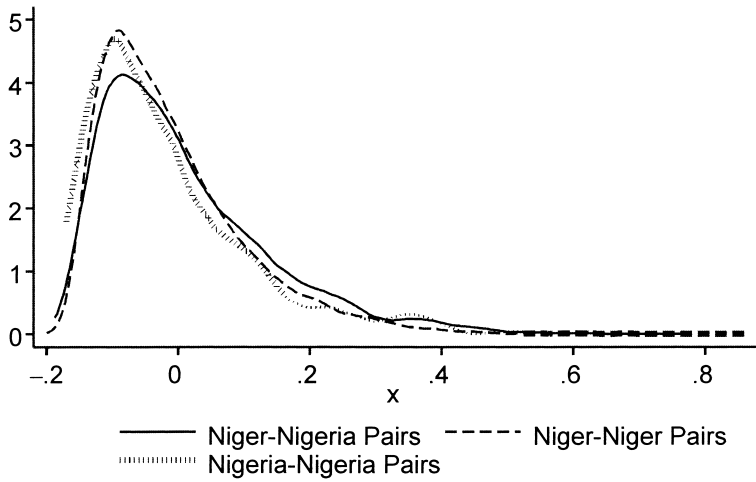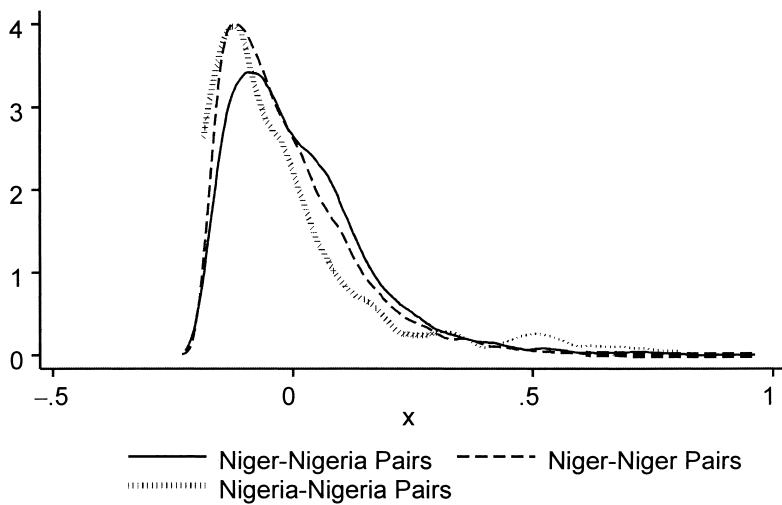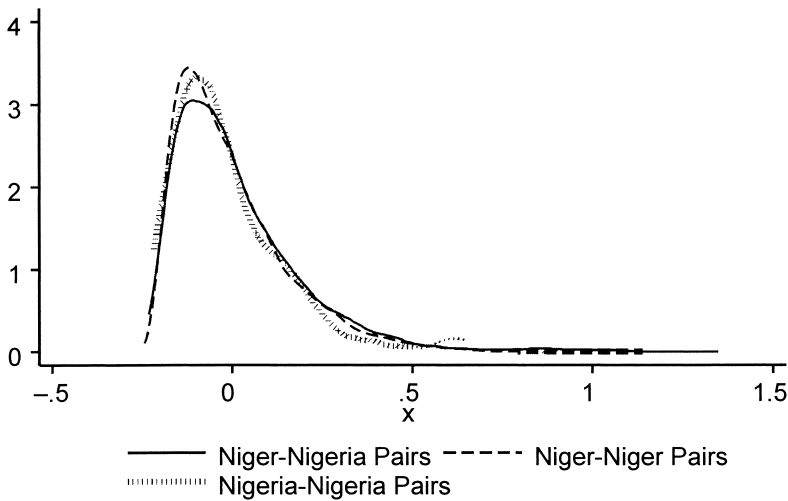
Fig. 6.2C   Kernel distributions of millet, sorghum, and cowpeas for Niger and Nigeria (1999–2006), ln price differences for intranational and cross-border market pairs: Cowpeas pairs < 300km: Residuals on ln(transport costs), urban, drought

kernel distributions suggests that the underlying volatilities of market-pair price differentials are similar across countries for grains and cowpeas. The distributions show a modest horizontal displacement across countries, suggesting that even if there is a statistically significant border effect, it may not be economically important.

These cross-sectional results, however, may mask differences across time. In particular, we are interested in investigating whether exchange rate movements between the naira and CFA franc alter relative prices, which would be consistent with a lack of full-market integration across the international border. There was a strong appreciation of the CFA franc relative to the naira between 1999 and 2001 and 2002 and 2004.[8] If cross-border markets were not well integrated, we would expect to see increases in the price of millet, sorghum, and cowpeas in Niger relative to those in Nigeria during these periods.[9]

To investigate conditional price dispersion over time, we estimate equation (1) for cross-border pairs separately for three marketing years (1999/2000, 2000/2001, and 2001/2002) using the observed price differences (rather than absolute values, as above) between Niger and Nigeria for millet, sorghum, and cowpeas, and plot the kernel distributions of the residuals from these

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8. There was a 16 percent appreciation of the CFA against the naira between 1999 and 2001.

9. Gopinath et al. (2009) find that relative costs of similar goods in Canada and the United States closely track the exchange rate.
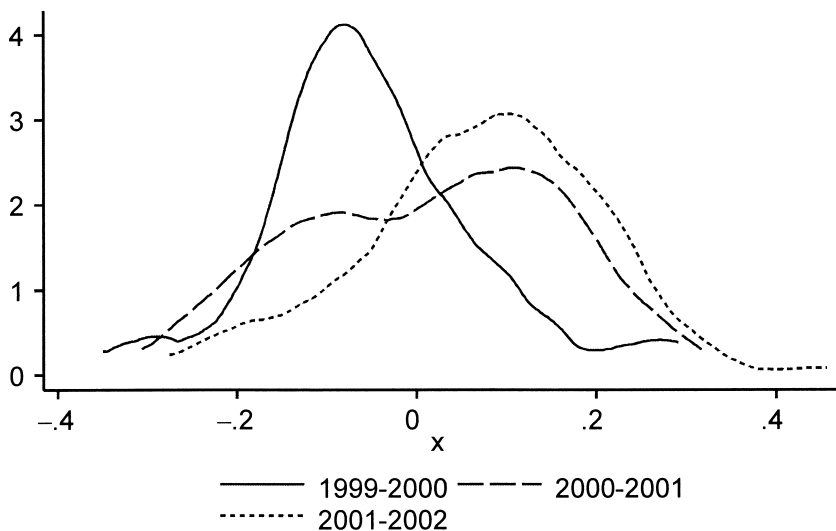
Fig. 6.3A   Kernel distributions for Niger-Nigeria market pairs by year (1999–2001), ln P(Niger) – ln P(Nigeria): Millet residuals on drought, distance < 100 km

regressions in figures 6.3A, 6.3B, and 6.3C. Figures 6.3A and 6.3B show a rightward shift in the distributions of millet and sorghum, respectively, between 1999/2000 and 2000/2001, the period during which there was an appreciation of the CFA/naira exchange rate. This suggests that relative prices follow the CFA franc-naira exchange rate, which could reflect a lack of market integration. A more formal test of market integration is offered by the regression analysis presented in the next section.

6.5   Regression Analysis

In this section we present a more precise analysis of the border effect, following the method of an early and influential contribution to this literature, Engel and Rogers (1996). They compare price dispersion for fourteen categories of goods among 228 market pairs (each pair represents two cities in the United States, two cities in Canada, or one in the United States and the other in Canada) through regressions with the specification:

$$(2) \qquad \sigma_{ij} = \beta_1 \ln(d_{ij}) + \beta_2 B_{ij} + \sum_{m=1}^{N} \gamma_m D_m + \varepsilon_{ij}$$

where σ_{ij} is a measure of price dispersion between cities i and j, d_{ij} is the distance between these cities, B_{ij} equals 1 if cities i and j are in different countries and 0 otherwise, and D_m is a set of city-specific dummy variables.

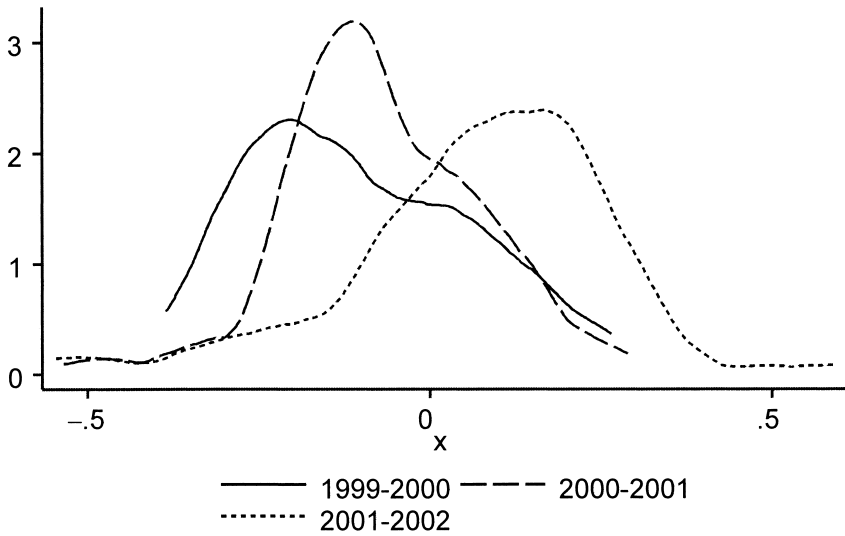**Fig. 6.3B   Kernel distributions for Niger-Nigeria market pairs by year (1999–2001), ln P(Niger) – ln P(Nigeria): Sorghum residuals on drought, distance < 100 km**

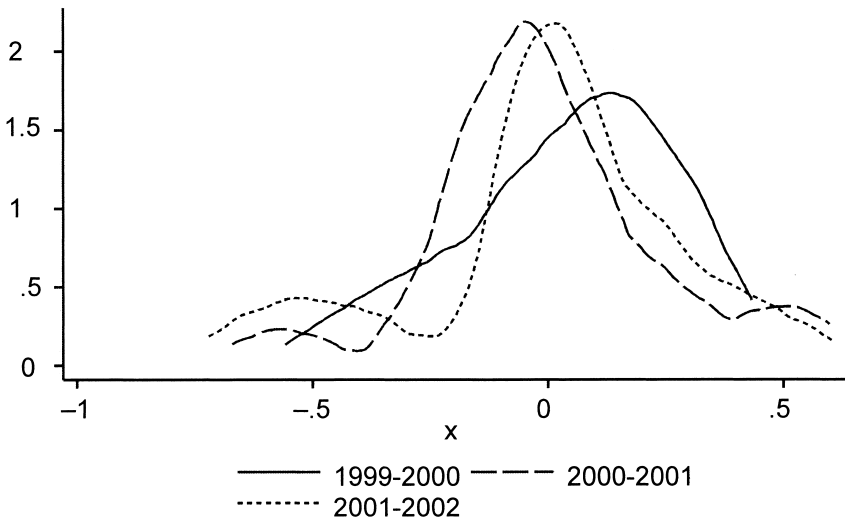**Fig. 6.3C   Kernel distributions for Niger-Nigeria market pairs by year (1999–2001), ln P(Niger) – ln P(Nigeria): Cowpeas residuals on drought, distance < 100 km**

The estimated coefficient β_2 represents the conditional change in price dispersion between two cities due to the fact that they are in different countries. The estimated border effect, that is, the distance-equivalent effect of the border, is $exp(\beta_1 / \beta_2)$.

Engel and Rogers find strikingly large effects of the international border on price dispersion; one estimate puts the distance-equivalent effect at over 70,000 km. Other research reports similar magnitudes for border effects between industrial countries. But Gorodnichenko and Tesar (2009) show that differences in underlying price volatility in two countries can result in an upwardly biased estimate of the border effect, since comparing cross-country pairs of prices reflects both differences in underlying price variability in one of the countries as compared to the other as well as the costs associated with crossing the border between the countries. They demonstrate that the inclusion of a dummy variable for pairs of locations within one country can result in very different estimates than those obtained when including a dummy variable for pairs of locations in the other country, if there are wide differences in price volatility across the two countries. For example, with the Engel and Rogers data, the estimated distance-equivalent border effect based on a specification that includes a Canada-Canada fixed effect is 47 km while the one based on a specification that includes a United States-United States fixed effect is 108 million km.

The Gorodnichenko and Tesar effect might be expected to be less of a concern for our analysis than for that of Engel and Rogers since, as shown in figures 6.2A, 6.2B, and 6.2C, the distribution of absolute price differences for Niger-Niger pairs differs very little from the distribution for Nigeria-Nigeria pairs. As will be shown, this conjecture is supported by a comparison of border effects between regressions that include a dummy variable for Niger-Niger pairs and those that use a dummy variable for Nigeria-Nigeria pairs.

To implement the Engel-Rogers approach, we estimate a version of equation (1) with a dummy variable for cross-border market pairs,

$$(3) \qquad \left| \ln(p_{jt}^i / p_{kt}^i) \right| = \beta_1 B_{jk} + \beta_2 X_{jkt} + \sum_{m=1}^{N} \gamma_m D_m + \theta_t + \varepsilon_{jkt}$$

where B_{jk} and D_m are defined as above, X_{jkt} is a vector of variables that might affect price dispersion between two markets, such as drought, road quality, transport costs, and other time-varying factors, and θ_t is a vector of monthly fixed effects. One version of this specification does not include a binary variable for country-specific pairs. In light of the Gorodnochenko-Tesar critique, we estimate two additional versions, one containing an indicator variable that equals 1 if both locations in the pair are in Niger, and the other containing an indicator variable that equals 1 if both locations in the pair are in Nigeria.

Table 6.2 shows the results of the regressions that take the form of equation (3). There is a separate panel for each of the three commodities. Column

Table 6.2   Estimated international border effects

Dependent variable: |ln (Pit/Pjt)|	Millet				Sorghum				Cowpeas			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Niger-Nigeria border	.026***	.026***	.026***	.020***	.023***	.021***	.024***	.024***	.029***	.029***	.029***	.023***
	(.002)	(.002)	(.002)	(.003)	(.003)	(.003)	(.003)	(.003)	(.003)	(.003)	(.003)	(.003)
Transport costs	.045***	.045***	.045***	.045***	.036***	.036***	.036***	.036***	.063***	.063***	.063***	.063***
	(.002)	(.002)	(.002)	(.002)	(.003)	(.003)	(.003)	(.003)	(.003)	(.003)	(.003)	(.003)
Drought dummy	.004	.004	.004	.004	.046***	.045***	.045***	.046***	-.040***	-.040***	-.040***	-.036***
	(.007)	(.007)	(.007)	(.007)	(.011)	(.011)	(.011)	(.011)	(.009)	(.009)	(.009)	(.009)
Urban status	-.009***	-.009***	-.009***	-.009***	-.008***	-.008***	-.008***	-.008***	-.009***	-.009***	-.009***	-.011***
	(.001)	(.001)	(.001)	(.001)	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)
Niger market		.002				.001						
		(.008)				(.011)						
Nigeria market			-.002				-.001				-.006	
			(.008)				(.011)				(.010)	
Cell phone coverage				-.005**				-.015***				-.030***
				(.002)				(.003)				(.003)
Border * cell phone coverage				.020***				.008				.004
				(.004)				(.005)				(.007)
Market-pair fixed effects	No	No	No	No	No	No	No	No	No	No	No	No
Monthly time dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of observations	21,460	21,460	21,460	21,460	15,662	15,662	15,662	15,662	20,421	20,421	20,421	20,421
R-squared	0.0797	0.0797	0.0897	0.0801	0.1081	0.1081	0.1081	0.1091	0.1036	0.1036	0.1036	0.1097
Joint effect of border and interaction				.040**				.032***				.027***
				(.004)				(.005)				(.006)

Notes: Data are from secondary sources and the Niger trader survey collected by Aker. Additional covariates include the presence of drought, mobile phone coverage, and urban status. All regressions are clustered by month to correct for spatial dependence between markets over time.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

(1) of each panel shows that the international border is associated with a statistically significant increase in price dispersion for each of the three commodities, contributing a 2.6 percent increase in price dispersion for millet, a 2.3 percent increase for sorghum, and a 2.9 percent increase for cowpeas. The magnitude and statistical significance of the border effect is robust to the inclusion of a binary variable that identifies Niger-Niger market pairs (column [2] in each panel) and another that identifies Nigeria-Nigeria market pairs (column [3] in each panel), suggesting that country-specific differences in price dispersion are not driving our results.[10]

The border effect could arise for a number of reasons. One reason is associated with the difficulty in obtaining timely information on prices across an international border. Aker (2010) has shown that, within Niger, the advent of mobile phone coverage led to a reduction in price dispersion. Does the same effect hold across the Niger-Nigeria border?

Evidence presented in column (4) of each panel shows that the mobile-phone effect does, in fact, hold internationally, as well as within countries. Column (4) augments the basic specification (in column [1]) with two binary variables. The first binary variable is equal to 1 if both markets have mobile phone coverage at time t, and is otherwise 0. The second is an interaction of the mobile phone coverage variable with the border dummy variable. In this specification, the excluded category is internal markets that do not have mobile phone coverage. The coefficient on the border dummy variable therefore represents the border effect for markets that cannot communicate by mobile phone (because at least one of the markets is not covered by mobile phone service), while the coefficient on the mobile phone coverage variable represents the effect of mobile phone coverage on internal market pairs. The border effect for market pairs that can communicate by mobile phone is given by the sum of the coefficients on the border dummy variable and the interaction variable.

The estimates presented in column (4) of each panel of table 6.2 show that mobile phone coverage is associated with a statistically significant decrease in price dispersion across internal markets for all three commodities.[11] Although mobile phones reduce price dispersion for internal market pairs, the border still "matters" for all commodities, even between markets that can communicate by mobile phone, since the joint effect of the border dummy variable and the interaction term remains positive and statistically significant. Not surprisingly, the border effect remains significant for market pairs that cannot communicate by mobile phone, again for all three com-

10. As discussed by Gorodnichenko and Tesar (2009), it is impossible to include the border dummy variable and both market-pair dummy variables because of multicollinearity. The results presented in this table are all robust to the use of dyadic standard errors.

11. Aker (2010) finds the introduction of mobile phones was associated with a negative and statistically significant reduction in price dispersion across millet markets within Niger, and that this effect was the strongest for markets located between 200 and 550 km apart.

modities, as shown by the positive and significant coefficients on the border dummy variable in the column (4) estimates.

6.6 Price Dispersion across Ethnic Regions in Niger

There has been a growing interest recently in economic research investigating the role that ethnic or cultural diversity can play in explaining socioeconomic outcomes. A number of empirical studies have found that ethnic diversity is associated with lower growth rates (Easterly and Levine 1997), more corruption (Mauro 1995), lower contributions to local public goods (Alesina, Baqir, and Easterly 1999), and lower participation in groups and associations (Alesina and La Ferrara 2000). In this section, we contribute to this stream of research by investigating whether ethnic diversity creates "internal borders" to trade, and hence market segmentation.

The process through which borders were established in West Africa resulted in multiple ethnic groups within Niger, as noted above. Also, as mentioned earlier, these ethnic groups generally live in geographically distinct regions of the country. We focus on two of the major ethnic groups in Niger, the Hausa and the Zarma, and consider whether there is a statistically significant and economically meaningful "border" between the regions they inhabit in Niger.

We identify the Hausa and Zarma regions of Niger through the use of both secondary and primary data on the ethnic composition of geographic locations within the country. We use the degree of ethnic diversity across locations to locate the ethnic Hausa/Zarma border as a linear spline running roughly south to north that separates two geographic locations with a low degree of ethnic diversity (i.e., a strong majority of Hausa or Zarma). Markets on the "border" are omitted from the analysis; they have a higher degree of ethnic diversity, that is, a more even mix between Hausa and Zarma, than markets on either side of the border.[12]

Having identified an intra-Niger ethnic border, we now analyze its economic consequences for price dispersion using the two methods employed above to study the effects of the Niger-Nigeria border. We begin with a graphical analysis. Figures 6.4A, 6.4B, and 6.4C show the kernel distributions of the ε_{jkt} of a specification like equation (1) but with a distinction between the Hausa and Zarma regions of Niger rather than the countries of Niger and Nigeria. In this case, the distinction is made between Hausa-Hausa market pairs in Niger, Zarma-Zarma market pairs in Niger, and

12. The measure of ethnic diversity used almost universally in the empirical literature is the index of ethnolinguistic fractionalization (ELF), which is a decreasing transformation of the Herfindahl concentration index. In particular, if we consider a society composed of K ≥ 2 different ethnic groups and let p_k indicate the share of group k in the total population, the resulting value of the ELF index is given by $1 - \Sigma(p_k)^2$. Thus, a lower value of the ELF index indicates a higher degree of ethnic homogeneity.
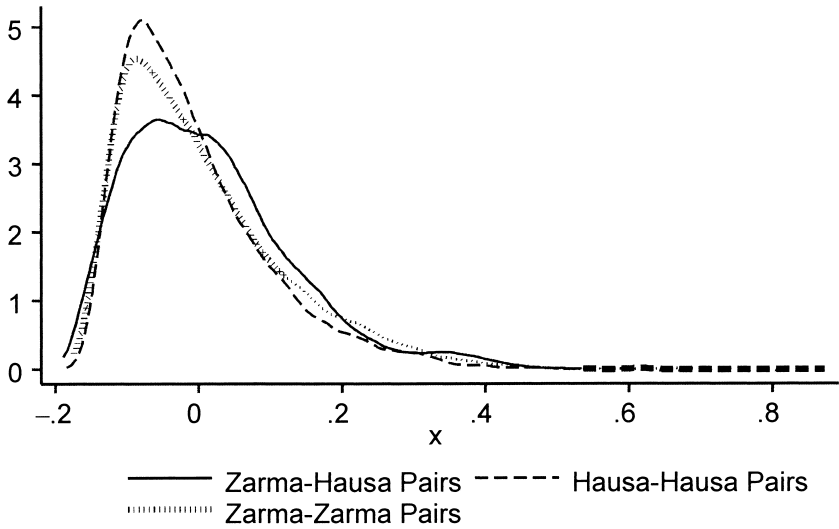
Fig. 6.4A Kernel distributions for Zarma and Hausa market pairs. Absolute ln price differences: Millet, intra-Niger, < 300km: Residuals on ln(TC), urban, drought

Fig. 6.4B Kernel distributions for Zarma and Hausa market pairs. Absolute ln price differences: Sorghum, intra-Niger, < 300 km: Residuals on ln(transport costs), urban, drought
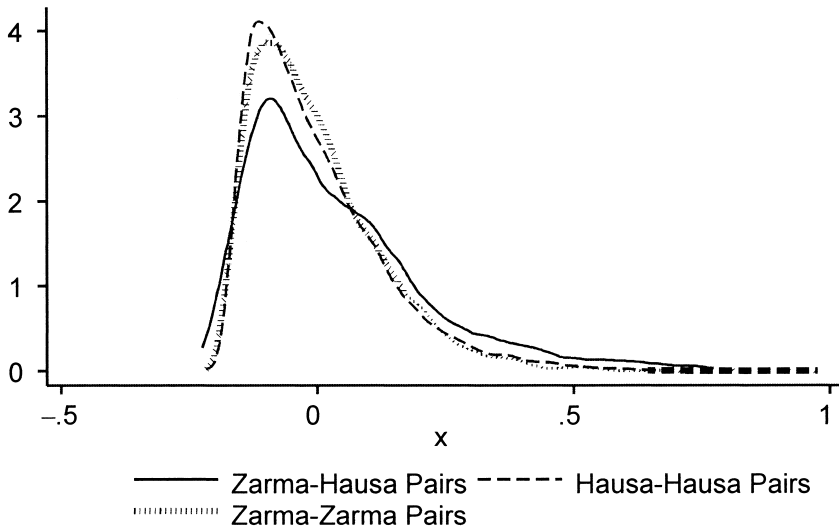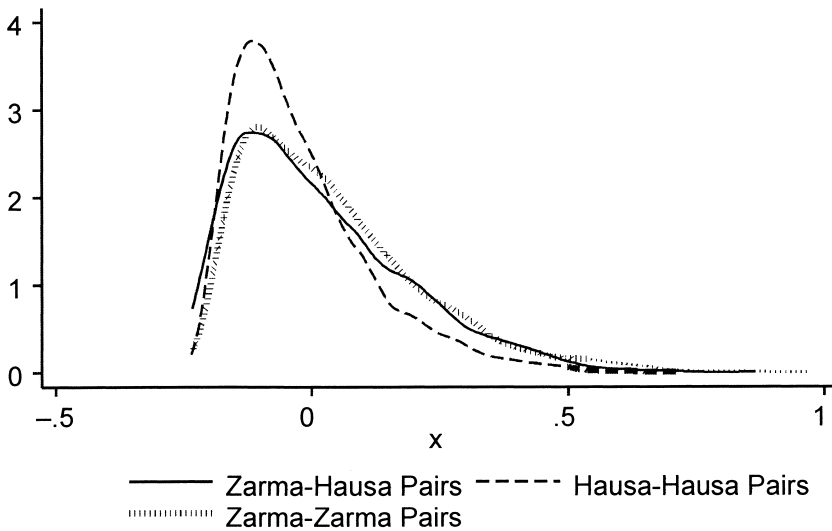
Fig. 6.4C   Kernel distributions for Zarma and Hausa market pairs. Absolute ln price differences: Cowpeas, intra-Niger, < 300 km: Residuals on ln(transport costs), urban, drought

cross-ethnic-border pairs that include one location in the Hausa region of Niger and the other in the Zarma region. These kernel distributions suggest that the underlying price dispersions for millet, sorghum, and cowpeas in each region are similar but, unlike the kernel distributions for Niger-Nigeria market pairs, the distribution of price dispersion between Zarma and Hausa markets seems markedly different than the distributions for intra-Hausa and intra-Zarma market pairs. This suggests that the internal Hausa-Zarma border may have greater consequences for price dispersion within Niger than the Nigerian border does for price dispersion between the two countries.

Regression estimates confirm this impression. The three panels of table 6.3 present the regression estimates of equation (3) for each commodity although, in this case, the sample only includes market-pair data from the Hausa and Zarma regions of Niger and the "border" represents the intra-Niger division between these two regions. These regression results show that this internal border is associated with a positive and statistically significant increase in price dispersion for each commodity. Column (1) of each panel shows that the internal ethnic border between the Hausa and Zarma regions is significant for all three commodities. The magnitude of this intranational ethnic border effect exceeds that of the international border effect in all cases; the estimated ethnic border effect is more than double the international border effect for millet, more than 60 percent larger for cowpeas, and

Table 6.3   Estimated internal border effects

Dependent variable: |ln (Pit/Pjt)|	Millet				Sorghum				Cowpeas			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Hausa-Zarma border	.056***	.061***	.043***	.052***	.026***	.024***	.037***	.026***	.047***	.060***	.018***	.037***
	(.006)	(.006)	(.006)	(.007)	(.003)	(.003)	(.004)	(.003)	(.006)	(.006)	(.01)	(.01)
Transport costs	.041***	.040***	.040***	.040***	.053***	.052***	.052***	.052***	.060***	.060***	.060***	.060***
	(.003)	(.003)	(.003)	(.003)	(.002)	(.002)	(.002)	(.002)	(.003)	(.003)	(.003)	(.003)
Drought dummy	.009	.011	.011	.009	.022**	.022**	.022**	.022**	-.024**	-.023**	-.023**	-.024**
	(.011)	(.010)	(.010)	(.011)	(.010)	(.010)	(.010)	(.010)	(.011)	(.011)	(.011)	(.011)
Urban status	-.006***	-.006***	-.006***	-.006***	.009***	.009***	.009***	.009***	-.007**	-.007**	-.007**	-.006**
	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)	(.003)	(.002)
Hausa market		-.018***				.012***				-.041***		
		(.002)				(.003)				(.003)		
Zarma market			.018***				.012***				.041***	
			(.002)				(.003)				(.003)	
Cell phone coverage				-.012***				-.017***				-.044***
				(.003)				(.003)				(.004)
Border * cell phone coverage				.019				.004				.052***
				(.016)				(.005)				(.014)
Constant												
Market-pair fixed effects	No	No	No	No	No	No	No	No	No	No	No	No
Monthly time dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of observations	10,829	10,829	10,829	10,829	26,262	26,262	26,262	26,262	13,195	13,195	13,195	13,195
R²	0.0873	0.0935	0.0935	0.0844	0.2362	0.2362	0.2362	0.2371	0.1176	0.1329	0.1329	0.1248
Joint effect of border and interaction				.071***				.030***				.090***
				(.014)				(.004)				(.012)

Notes: Data are from secondary sources and the Niger trader survey collected by Aker. Cell phone dummy = 1 when both markets have cell phone coverage, 0 otherwise. Drought dummy = 1 in period t when one market in a pair has rainfall less than or equal to two standard deviations below its average rainfall level during the rainy season, or fifteen consecutive days without rainfall during the rainy season, 0 otherwise. Urban status = 1 if one market in a pair is an urban center (> = 35,000 people), 0 if both or neither are urban centers. Regressions include all market pairs no more than 250 km apart. Huber-White robust standard errors clustered by market-pair month (price difference) are in parentheses. All prices are in CFA francs deflated by the Nigerien Consumer Price Index.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

more than 10 percent larger for sorghum. As with the estimates presented in table 6.2, the significance of these results is robust to the inclusion of region-specific fixed effects for intra-Hausa (column [2]) and intra-Zarma (column [3]) market pairs, although the value of the effect is sensitive to the inclusion of these fixed effects in the case of cowpeas. This is consistent with the visual inspection of the kernel distributions in figure 6.4C, which suggested that the underlying price dispersion for cowpeas differed considerably in intra-Hausa and intra-Zarma regions.

Mobile phone coverage diminishes price dispersion within regions. In all three panels in table 6.3, the coefficient on the mobile phone coverage variable is significant and negative, suggesting that mobile phones reduce price dispersion within the Hausa region and within the Zarma region (Aker 2010). The magnitude of this reduction is notable, and equal to 1.2 percent for millet, 1.7 percent for sorghum, and 4.4 percent for cowpeas. But there is less evidence that the reduction in price dispersion occurs across markets on either side of the internal ethnic border: the joint effect of the mobile phone dummy variable and the interaction term is negative and statistically significant for sorghum. While this suggests that mobile phones are less useful across ethnic regions than within them, the result may be confounded to some degree with a nonlinear effect of distance. The cross-border market pairs in these regressions are less than 250 km apart, and Aker (2010) found that mobile phones reduced price dispersion primarily for medium-haul markets, namely, those between 200 and 500 km apart. The joint effect of the border and interaction term, capturing the impact of the internal border on markets connected by mobile phones, remains positive and statistically significant for all specifications.

We might be concerned about potential bias due to correlation between the internal border effect and unobserved covariates. The lower panel of table 6.4 tests for the equality of means of market-level covariates on either side of the internal border. We fail to find evidence of a statistically significant difference for most market-level covariates, including market size, the frequency of drought, road quality, distance between markets, and urban status. The notable exception is mobile phone coverage, with a strong statistically significant difference between the two groups.

6.7   Conclusion

This chapter began by asking whether international market integration is feasible in sub-Saharan Africa. We find evidence of an international border effect between Niger and Nigeria, but the magnitude of this effect is much smaller than that found in industrialized countries. Thus, the border does not pose a deep threat to the success of existing regional economic commissions that have attempted to foster cross-border trade, even when two countries do not share a common currency. These results suggest that the

Table 6.4   **Comparison of observables by ethnicity (within Niger)**

Observables	Unconditional mean		Difference in means
	Mean (s. d.)	Mean (s. d.)	Unconditional s. e.
A. Market-pair-level data	**Hausa-Hausa**	**Zarma-Zarma**	
Distance between markets (km)	234.08(134)	216.42(161)	17.66(21.54)
Road quality between markets	.43(.49)	.41(.49)	.02(.07)
Cell phone coverage	.81(.39)	.98(.12)	−.17***(.03)
Transport costs between markets (CFA/kg)	8.08(4.34)	7.54(5.06)	.53***(.07)
B. Market-level data	**Hausa**	**Zarma**	
Millet price level (CFA/kg)	123.23(30)	139.01(32)	−15.77***(1.56)
Sorghum price level (CFA/kg)	112.84(32)	134.82(36)	−21.98***(1.90)
Cowpeas price level (CFA/kg)	162.58(48.97)	197.94(55)	−35.37***(2.60)
Road quality to market	.87(.35)	.6(.52)	.28(.21)
Market size	107.63(86)	70.1(50)	37.53(34.43)
Cell phone coverage (2007)	.43(.50)	.35(.48)	.08***(.02)
Drought between 1999–2007	.031(.174)	.031(.174)	−.0000(.008)
Urban center(> = 35,000)	.5(.53)	.4(.52)	.1(.25)

Notes: Data are from secondary sources and the Niger trader survey collected by Aker. In panel A, "Hausa" market pairs are pairs where both markets are located in Hausa regions of Niger, and "Zarma" market pairs are pairs where both markets are located in the Zarma region of Niger. In panel B, "Hausa" markets are markets with a majority of Hausa traders within Niger, and "Zarma" markets are markets with a majority of Zarma traders within Niger. Huber-White robust standard errors are clustered by market-pair month (panel A), and market month (panel B) are in parentheses. All prices are CFA francs deflated by the Nigerien Consumer Price Index. The Kolmogorov-Smirnov test tests for the equality of the distribution functions.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

Walrasian auctioneer can be heard across the Niger-Nigeria border. Her voice carries especially well within her ethnic community, or with the aid of a mobile phone.

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