GEORG-AUGUST-UNIVERSITÄT GÖTTINGEN

GlobalFood
www.uni-goettingen.de/globalfood

RTG 1666 GlobalFood

Transformation of Global Agri-Food Systems:
Trends, Driving Forces, and Implications for Developing Countries

Georg-August-University of Göttingen

GlobalFood Discussion Papers

No. 38

Proximity and price co-movement in West African rice markets

Carolin Mengel
Stephan von Cramon-Taubadel

May 2014

RTG 1666 GlobalFood · Heinrich Düker Weg 12 · 37073 Göttingen · Germany
www.uni-goettingen.de/globalfood

ISSN (2192-3248)

Proximity and price co-movement in West African rice markets

Carolin Mengel, Stephan von Cramon-Taubadel [1]

Department of Agricultural Economics and Rural Development
University of Göttingen

[1] Corresponding authors: Carolin Mengel (carolin.mengel@agr.uni-goettingen.de), Stephan von Cramon-Taubadel (scramon@gwdg.de). Carolin Mengel is a Research Associate with the GlobalFood Research Training Group and gratefully acknowledges funding by the German Research Foundation (DFG). We also thank the German Research Foundation (DFG) for the funding and the International Food Policy Research Institute (IFPRI) in Dakar for the feedback and the provided infrastructure. Moreover, we thank Maximo Torero, Tanguy Bernard, Ismael Fofana, Fousseini Traoré, Anatole Goundan, Jenny Aker and Dembo Kouyaté for useful feedback, support and assistance.

Abstract

This study explores the link between proximity and price cointegration between two markets, where proximity is captured with variables for geographical, political and cultural distance. Linear and threshold cointegration is tested for a set of 756 rice market pairs in 6 West African countries, with threshold specifications accounting for transaction costs. Whether proximity influences price transmission is determined in a second step with a multinomial logistic regression. The estimation produces robust and statistically significant evidence of a link with air-line and road distance, international borders, contiguity and a common language. We conclude that proximity matters for market integration processes in West African rice markets.

JEL:

C32, D23, L11, Q11, Q17

Keywords:

West Africa, cointegration, developing countries, agricultural trade, rice, commodity prices, transaction costs, regional integration

1. Introduction

The relationship between market proximity and integration is widely acknowledged in the trade volume literature. The closer two markets are in terms of geographical, political and cultural distance, the more they trade. However, the influence of proximity has not yet been clearly documented in the price transmission literature. Whether and how price signals are transmitted between markets may partly depend on geographical, political, cultural factors. This study proposes an approach to examine this link. We seek to identify the empirical determinants of commodity market integration.

We study rice markets in West Africa, where both imported and local rice are relevant staple crops and widely traded. The region is both with economically and politically relevant. West Africa is a food deficit area and local market integration plays an important role in cushioning shortages or food price shocks. Moreover, stabilizing local food production is a political goal in most West African countries, all of which were affected by high import prices in recent years. Net food importing countries are particularly vulnerable to global food price shocks. An improved understanding of price dynamics and market integration in the area can contribute to policy formulation regarding price interventions, infrastructure, border management and trade enhancing measures.

2. Theory and literature

Fackler and Goodwin (2001) define market integration as “the measure of the degree to which demand and supply shocks arising in one region are transmitted to another region”. Price transmission analysis studies in particular price dynamics between markets reflecting such shocks. Price transmission may take place as a result of physical trade due to arbitrage, either directly or via third markets. It can also take place in the absence of trade flows as a result of communication or the flow of information (Jensen, 2007; Stephens et al., 2012).

Over time price transmission manifests itself as some sort of co-movement of prices in the respective markets. Since Ardeni (1989) this co-movement has overwhelmingly been modelled using cointegration techniques. In the case of price transmission between two geographically separated markets (spatial price transmission), so-called threshold error correction models (TVECMs) are commonly employed. The TVECM allows modelers to explicitly account for the costs of trade between two locations. If the prices differ by more than these costs, trade is triggered between the markets. Parts employ the TVECM to combine a band or regime of price transmission, within which prices co-move as a result of trade or information flows, with a neutral band within which prices move independently of one another (Greb et al., 2013). However, such a neutral band as the absence of price transmission is not a necessary requirement for the model. It is sufficient if price transmission changes significantly when the price change exceeds a certain threshold value. One possible explanation would be that individual trade costs for market actors differ and an increase in the profit margin attracts more competition spurring price transmission.

Whether and how prices on spatially separate markets move together is thus closely related to the costs of trade and communication between these markets. Definitions of these costs and the theoretical link with trade can be derived from trade literature. Anderson and Van Wincoop (2004) classify trade costs as (I) transportation costs such as gas and tolls, (II) trade barriers such as custom procedures and tariffs and (III) transaction costs such as long distance phone calls and translation. Gravity models explicitly link trade volumes to both size and proximity of markets. Proximity has a geographic dimension, but cultural similarities such as a shared language can also indicate a form of proximity. For the West African region, Zannou (2010) finds that commodity trade between markets falls with increasing distance between them and if they are separated by an international border. He also finds that a common official language and contiguity are positively correlated with trade volume. In this strand of the literature, the explanation given is that trade costs increase with distance and decrease commercial activity and communication. This link between distance/borders, trade costs, and trade volumes has been confirmed in many studies.

A related perspective on the link between prices and the proximity of markets can be derived from the literature on price disparities. A number of studies concern themselves with distance and border effects and deviations from the Law of One Price. The seminal paper by Engel and Rogers (1995) finds that a border has the same effect on price disparities as 2500 kilometers of distance. Similarly, Aker et al. (2013) finds a statistical link from borders to price disparities between markets Niger and Nigeria.

Very few studies have attempted to test whether proximity and borders affect not trade volumes or price differentials between markets, but rather whether there is price transmission between these markets. If proximity and borders affect trade and information flows between markets, then it is reasonable to expect that they will also affect the process of price transmission between these markets. Hernandez-Villafuerte (2011) finds a significant negative effect of road distance on the size of the cointegrating elasticity between Brazilian rice markets.

In a meta-analysis of the spatial price transmission literature, (Mengel & von Cramon-Taubadel, 2014) find that geographic distance and separation by an international border affect the likelihood of cointegration between the prices on two markets. According to the results, the likelihood of cointegration is 23% lower if the markets in question are separated by an international border. Furthermore, each additional 1000 kilometer distance between two markets within a country decreases the likelihood of cointegration by 7%. The authors use meta-analysis to take advantage of the extensive empirical literature on price transmission to test for distance and border effects. However, meta-analysis is made difficult by the fact that different price transmission studies use different estimation approaches and different types of data, with the result that their findings are not always directly comparable. Furthermore, meta-analysis is susceptible to publication bias in the literature it evaluates, and to often incomplete documentation of methods and results in published studies. Hence, the aim of this paper is to complement the meta-analysis in Mengel and von Cramon-Taubadel (2014) with empirical estimates of distance and border effects in price transmission. To this end we test for the presence of distance and border effects on the transmission of rice prices between markets in Western Africa.

3. Methods and data

We employ 28 monthly rice price series from Benin, Mauretania, Niger, Chad, Senegal and Togo. We consider only pairs of prices for imported rice. Research has demonstrated that local and imported rice varieties are not close substitutes (M. Demont et al., 2012; Matty Demont et al., 2013). The resulting product heterogeneity might confound the effects we want to isolate. We restrict the analysis to series with at least 100 observations and less than 10% missing values. The price series are taken from the FAO-GIEWS, USDA-FEWS and UN-WFP VAM databases. Most of the series start in the early 2000s and end in 2012 or 2013. The markets considered are retail markets with the exception of one wholesale market in Niger (Maradi2, see Table 1). To ensure comparability we convert all series into CFA (XOF) and per kilogram terms. Individual plots of the price series are provided in the Appendix.

Table 1: Descriptive statistics and unit-root tests of price series

Series label	Country	Start	End	Missing values	t-stat ADF (level)	t-stat ADF (diff)	
Abomey	Benin (BEN)	Aug 95	Oct 13	6.8% (15)	0.754	-11.964	***
Cotonou	Benin (BEN)	May 95	Oct 13	-	1.198	-13.101	***
Natitingou	Benin (BEN)	May 95	Oct 13	3.6% (8)	0.887	-11.556	***
Moussoro1	Chad (TCD)	Oct 03	Oct 13	-	0.096	-13.070	***
NDjamena1	Chad (TCD)	Oct 03	Oct 13	-	-0.170	-11.065	***
Moussoro2	Chad (TCD)	Jan 02	Jun 13	-	-0.103	-12.252	***
NDjamena4	Chad (TCD)	Jan 02	Jun 13	-	-0.062	-12.056	***
Nouakchott1	Mauritania (MRT)	Oct 03	Oct 13	5.8% (7)	0.088	-7.161	***
Nouakchott2	Mauritania (MRT)	Apr 03	Jun 13	4.1% (5)	0.161	-9.533	***
Agadez1	Niger (NER)	May 95	Apr 12	-	1.198	-11.579	***
Dosso	Niger (NER)	May 95	Apr 12	2% (4)	0.970	-11.309	***
Maradi1	Niger (NER)	May 95	Apr 12	-	1.209	-11.058	***
Niamey1	Niger (NER)	Jan 00	Apr 12	-	0.732	-9.190	***
Zinder1	Niger (NER)	Jan 00	Apr 12	-	1.551	-9.680	***
Agadez2	Niger (NER)	Jan 02	Jun 13	0.7% (1)	1.020	-8.132	***
Maradi2	Niger (NER)	Oct 03	Jun 13	-	1.098	-8.018	***
Niamey2	Niger (NER)	Oct 03	Jun 13	-	0.683	-9.014	***
Zinder2	Niger (NER)	Oct 03	Jun 13	-	1.343	-9.142	***
Dakar	Senegal (SEN)	Oct 03	Jun 13	-	-0.095	-9.310	***
Kaolack	Senegal (SEN)	Oct 03	Jun 13	-	-0.068	-8.459	***
StLouis	Senegal (SEN)	Oct 03	Jun 13	-	-0.128	-7.562	***
Ziguinchor	Senegal (SEN)	Oct 03	Jun 13	-	-0.039	-7.066	***
Amegnran	Togo (TGO)	Jan 01	Nov 13	-	0.441	-13.020	***
Anie	Togo (TGO)	Jan 01	Nov 13	-	-0.012	-11.648	***
Cinkasse	Togo (TGO)	Jan 01	Nov 13	-	0.472	-11.831	***
Kara	Togo (TGO)	Jan 01	Nov 13	-	0.242	-11.774	***
Korbongou	Togo (TGO)	Jan 01	Nov 13	1.9% (3)	0.347	-12.227	***
Lome	Togo (TGO)	Jan 01	Nov 13	-	-0.054	-10.765	***

Note: Augmented Dickey-Fuller test statistics are presented for the series in levels and in first differences. Critical value for the null hypothesis of a unit root is -1.95 for a 5% level of significance. Results indicate non-stationarity of all series at the 1% level.

We linearly interpolate all missing values. After interpolation, all of the series contain between 105 and 222 observations and cover between 8 and 18 years. The Augmented Dickey Fuller test (Dickey & Fuller, 1979) fails to reject the null-hypothesis of a unit root in all of the price series in levels, but rejects this null-hypothesis for all of the series in first differences (Table 1). Table 2 lists the different tests and hypotheses used on univariate and bivariate price series.

Table 2: Linear and nonlinear cointegration tests applied to the West African rice prices

Author	H0:	H1:
Johansen (1988)	no cointegration	linear cointegration
Hansen & Seo (2002)	linear cointegration	threshold cointegration (2 regime TVECM)
Seo (2006)	no cointegration	threshold cointegration (BAND-TVECM)
Larsen (2012)	linear cointegration	2 threshold cointegration (3 regime TVECM)

Note: The tests were implemented with the statistical software R and the R-packages urca and tsDyn and test results were obtained at the 5% level of significance.

The 28 price series are combined to form market pairs for the subsequent analysis. In each pair one or both price series are trimmed to the same length. This results in 378 bivariate market pairs, of which 311 are separated by an international border and 67 are domestic price pairs from one of the sample countries. We test each price pair for linear and threshold cointegration (Table 2). The term threshold cointegration can be misleading because it suggests some sort of nonlinear cointegrating relationship, for example as proposed by Gonzalo and Pitarakis (2006). However, it is an established term in the literature for describing linear cointegration with threshold effects in the adjustment.[2] Hereafter, we will use it in the same way.

The threshold cointegration test results are sensitive to the order of the two price components. Each price pair is therefore tested a second time in reverse order, thus producing an overall sample of 756 observations. For all tests, the number of lags is selected according to the Bayesian information criterion (BIC). We use the Johansen test (Johansen, 1988) to test for linear cointegration. To carry out this test we restrict the cointegrating vector to equal [1, -1] and include no constant in the long-run relationship. Since linear cointegration cannot account for trade costs in spatial price transmission, we also use three tests for threshold cointegration. First, the Hansen & Seo test tests the null-hypothesis of linear cointegration against the alternative of threshold cointegration with one threshold. In other word, the rejection of the null indicates superiority of a two-regime TVECM compared to a linear VECM specification. We also use an extended Hansen & Seo test proposed by Larsen (2012) that allows for two possibly asymmetric thresholds. This TVECM specification has been used in recent studies (Greb et al., 2013) and is able to account for possible asymmetry in transaction costs depending on the direction of trade. Finally, we also employ a test developed by Seo (2006) which tests the null hypothesis of no cointegration against the alternative hypothesis of threshold cointegration. Together, these four tests cover the variety of model specifications that are currently and commonly employed in the spatial price transmission literature.

Using the results of these tests we explore the link between proximity and cointegration between two prices using the following basic specification:

$$Cointegration = f(proximity) \quad (1)$$

The specification of the covariates that measure proximity in equation (1) is based on the theoretical considerations discussed above, the literature on the determinants of trade volumes, and the literature on distance and border effects. To measure the physical distance between two markets, both air-line distance and road distance measures are chosen. These are obtained with an online distance calculator (www.distance.to), based on Google maps API. For the estimation, physical distance is measured in 1000 km. All remaining covariates are obtained from Mayer and Zignago (2011) often referred to as CEPII data set. The two variables for borders and contiguity distinguish between the presence of at least one international border between two markets (border = 1), and whether the two countries in question share this border (contiguity = 1). Hence, the border dummy takes the value 0 for market pairs located in the same country and 1 otherwise, and as a subset of those cases for which border = 1, the contiguity dummy takes the value 1 if the countries in question are direct neighbors. All other things being equal, trade between neighboring countries will be facilitated by established trade routes, including perhaps smuggling, compared with trade across two or more borders. As measures of cultural proximity we include a dummy variable that equals one if the countries in question share a language.

[2] Gonzalo and Pitarakis (2006) propose a model that includes threshold effects in the cointegrating relationship between two variables, rather than in the corresponding error correction mechanism.

Table 3: Summary statistics of market pair variables

Variable	N	Mean	St. Dev.	Min	Max
linear cointegration	756	0.247	0.432	0	1
threshold cointegration	756	0.263	0.441	0	1
1000 km air-line distance	756	1.407	0.952	0.00	3.658
1000 km road distance	756	1.900	1.276	0.00	4.922
Border (yes = 1, otherwise 0)	756	0.823	0.382	0	1
Contiguity (yes = 1, otherwise 0)	756	0.235	0.425	0	1
same language (yes = 1, otherwise 0)	756	0.754	0.431	0	1

Note: Air-line and road distance were obtained with the online distance calculator www.distance.to. Contiguity and same official or ethnological language are variables obtained from Mayer and Zignago (2011).

There is collinearity in this set of covariates. First, market pairs that are geographically proximate are more likely to be located in the same country (border = 0). Second, countries in West Africa that were colonies of the same foreign power are more likely to share a common language. Third, the language variable is measured at the country level (Mayer & Zignago, 2011) and consequently takes the same value (language = 1) for all domestic market pairs (border = 0). These correlations can influence parameter estimates and need to be kept in mind when interpreting the results presented in the next section.

4. Results

4.1. Results of linear and threshold cointegration tests

Table 4 provides an overview of the prevalence of linear and threshold cointegration between the domestic and cross-border market combinations. In some combinations, more price pairs show linear than threshold cointegration, while for others it is the other way around. A few examples illustrate this in more detail. In Benin all six possible pairs of domestic prices appear to be linearly cointegrated, but only two exhibit threshold effects in the adjustment. Hence, there is evidence that the magnitude of the deviation influences the speed of price transmission in only two of these pairs. As explained above, such a switch of the price adjustment regime is usually attributed to the role of trade costs. In all other pairs it appears that deviations from the long-run equilibrium are corrected with comparable speed, regardless of their magnitude. In the case of Senegal and Benin, none of the 12 market pairs appears to be linearly cointegrated, but in three pairs there is evidence of error correction if price differences exceed a threshold value. Whether and how proximity and borders influence these results is examined in the next section.

Table 4: Share and number of linearly cointegrated (LC) and threshold cointegrated (TC) market pairs by countries

	Benin		Mauritania		Niger		Senegal		Chad		Togo	
	LC	TC	LC	TC	LC	TC	LC	TC	LC	TC	LC	TC
BEN	100% 6 of 6	33% 2 of 6	0% 0 of 6	0% 0 of 6	52% 14 of 27	30% 8 of 27	0% 0 of 12	25% 3 of 12	100% 12 of 12	58% 7 of 12	61% 11 of 18	11% 2 of 18
MRT	0% 0 of 6	0% 0 of 6	0% 0 of 2	0% 0 of 2	0% 0 of 18	0% 0 of 18	0% 0 of 8	0% 0 of 8	25% 2 of 8	38% 3 of 8	0% 0 of 12	33% 4 of 12
NER	52% 14 of 27	33% 9 of 27	0% 0 of 18	0% 0 of 18	44% 32 of 72	43% 31 of 72	0% 0 of 36	6% 2 of 36	94% 34 of 36	61% 22 of 36	41% 22 of 54	9% 5 of 54
SEN	0% 0 of 12	25% 3 of 12	0% 0 of 8	0% 0 of 8	0% 0 of 36	11% 4 of 36	100% 12 of 12	42% 5 of 12	63% 10 of 16	25% 4 of 16	13% 3 of 24	13% 3 of 24
TCD	100% 12 of 12	58% 7 of 12	25% 2 of 8	38% 3 of 8	94% 34 of 36	58% 21 of 36	63% 10 of 16	31% 5 of 16	67% 8 of 12	50% 6 of 12	71% 17 of 24	42% 10 of 24
TGO	61% 11 of 18	11% 2 of 18	0% 0 of 12	25% 3 of 12	41% 22 of 54	7% 4 of 54	13% 3 of 24	13% 3 of 24	71% 17 of 24	42% 10 of 24	60% 18 of 30	27% 8 of 30
Sum	***53%*** ***43 of 83***	***28%*** ***23 of 83***	***4%*** ***2 of 54***	***11%*** ***8 of 54***	***42%*** ***102 of 243***	***28%*** ***68 of 243***	***23%*** ***25 of 108***	***17%*** ***18 of 108***	***77%*** ***83 of 108***	***48%*** ***52 of 108***	***44%*** ***71 of 162***	***20%*** ***32 of 162***

Note: LC stands for linear cointegration and TC for threshold cointegration. Price pairs can display evidence of both linear and threshold cointegration without contradiction. The percentage share refers to the market pairs tested positively for linear or threshold cointegration, e.g. 0 out of 12 Senegalese-Beninese market pairs are linearly cointegrated (0%) and 3 out of 12 (or 25%) are threshold cointegrated. The results are not necessarily symmetric as test results can differ in finite samples depending on the order of the two prices in a pair.

4.2. The influence of proximity and borders on the prevalence of cointegration

To facilitate the estimation of the model in equation (1), we code the cointegration test results presented above into three categories. Each price pair is either not cointegrated (48.9%), linearly cointegrated (24.7%) or threshold cointegrated (26.3%). We assign those market pairs for which tests find both linear and threshold cointegration to the threshold cointegration group. This is based on the formulation of the Hansen & Seo test (2002) and the Larsen test (2012) of threshold cointegration against the alternative hypothesis of linear cointegration which indicates that the more flexible threshold cointegration model fits the adjustment process more precisely.

Hence, the dependent variable on the left-hand-side of equation (1) is a qualitative variable that can take on three values. We estimate this model using multinomial logistic regression. An ordered logit would not be suitable since the three categories form no genuine order. The estimated marginal effects can be interpreted as the increasing or decreasing likelihood (in %) that a market pair belongs to one category rather than to the base. Since the base outcome is no cointegration, positive marginal effects can be interpreted as evidence of the increasing likelihood of some form of cointegration and, thus, price co-movement.

In Table 5 we first present results for all market pairs, both domestic and cross-border. In Table 6 we present results exclusively for the cross-border market pairs. We repeat the analysis exclusively for the cross-border pairs because one of the dummies variables for proximity (language) naturally always equal 1 for all domestic market pairs.[3]

[3] The regressions were also estimated with country dummies, but these proved to be highly collinear with the covariates for proximity and borders.

Table 5: Marginal effects according to the multinomial logistic estimation with national and international market pairs

	(1)	(1a)	(2)	(2a)	(3)	(4)
linear cointegration: 1000km air-line distance	-0.122*** (0.017)	-0.096*** (0.029)				
threshold cointegration: 1000km air-line distance	-0.041** (0.017)	-0.072*** (0.023)				
linear cointegration: 1000 km road distance			-0.091*** (0.013)	-0.071*** (0.023)		
threshold cointegration: 1000 km road distance			-0.030** (0.012)	-0.055*** (0.018)		
linear cointegration: border					-0.108** (0.044)	-0.137*** (0.047)
threshold cointegration: border					-0.152*** (0.045)	-0.184*** (0.048)
linear cointegration: contiguity						0.154*** (0.042)
threshold cointegration: contiguity						0.160*** (0.042)
country dummies		Yes		Yes		
Observations	756	756	756	756	756	756
Pseudo-R^2	0.055	0.212	0.054	0.212	0.020	0.058
Log Likelihood	-747.744	-623.177	-748.159	-623.422	-775.798	-745.627
LR chi2(2)	86.95*** (df=2)	336.08*** (df=12)	86.12*** (df=2)	335.59*** (df=12)	30.84*** (df=2)	91.18*** (df = 4)

*Note: Base outcome is no cointegration according to the tests. Rather than coefficients, average marginal effects of a multinomial logistic estimation are reported, with standard errors in brackets. *, ** and *** refer to significance at the 10%, 5% and 1% levels, respectively.*

Table 5 shows that distance has a negative effect on the likelihood of linear error correction, and a similar but somewhat weaker effect on the likelihood of threshold error correction. The magnitudes of these effects are somewhat stronger for air compared with road distance. Specifically, linear cointegration of two prices becomes 12.2% less likely with each additional 1000 kilometer geodesic distance. Threshold cointegration becomes 4.1% less likely. The inclusion of country dummies into the model reduces the magnitude of the first effect to -9.6%, and increases the magnitude of the second to -7.2%.Table 5 also shows that the likelihood of linear or threshold error correction falls if the markets in question are separated by an international border, and increases if the countries in question are contiguous. Prices are 10.8% less likely to display cointegration with linear error correction and 15.2% less likely to display cointegration with threshold error correction if they are recorded on markets that are separated by an international border. For contiguous countries, an overland transport route might be possible while countries without a common border require either transit through third countries or sea transport. The border effect becomes almost three percentage points stronger and more distinct if we control for contiguity of the countries. Contiguity itself increases the likelihood of both forms of cointegration by 15.4% and 16.0%, respectively.

The second sample includes only cross-border market pairs to control for possible multicollinearity between border and language variables, as previously explained.

Table 6: Results of multinomial logistic estimation with international market pairs

	(5)	(5a)	(6)	(6a)	(7)	(7a)	(8)	(8a)
linear cointegration:	-0.138***	-0.108**				-0.130***		-0.138***
1000 km air-line distance	(0.019)	(0.043)				(0.024)		(0.019)
threshold cointegration:	-0.017	-0.033				0.060**		-0.015
1000 km air-line distance	(0.018)	(0.029)				(0.024)		(0.018)
linear cointegration:			-0.103***	-0.073**				
1000 km road distance			(0.014)	(0.034)				
threshold cointegration:			-0.013	-0.030				
1000 km road distance			(0.014)	(0.022)				
linear cointegration:					0.168***	-0.005		
contiguity					(0.040)	(0.040)		
threshold cointegration:					0.173***	0.265***		
contiguity					(0.040)	(0.055)		
linear cointegration:							0.250***	0.249***
same language							(0.018)	(0.017)
threshold cointegration:							0.111**	0.111**
same language							(0.051)	(0.050)
country dummies		Yes		Yes				
Observations	622	622	622	622	622	622	622	622
Pseudo-R^2	0.051	0.246	0.050	0.245	0.048	0.074	0.030	0.083
Log Likelihood	-597.68	-475.01	-598.20	-475.27	-599.68	-583.31	-611.06	-577.52
LR chi2(2)	64.35***	309.70***	63.31***	309.16***	60.34***	93.10***	37.58***	104.67***
	(df=2)	(df=12)	(df=2)	(df=12)	(df=2)	(df=4)	(df=2)	(df=4)

*Note: Base outcome is no cointegration according to the tests. Rather than coefficients, average marginal effects of a multinomial logistic estimation are reported, with standard errors in brackets. *, ** and *** refer to significance at the 10%, 5% and 1% levels, respectively. Detailed results for intercepts and country variables are omitted from the table but can be found in the appendix. The regressions 7, 7a, 8 and 8a were also estimated*

The results in Table 6 confirm that the likelihood of linear and the likelihood of threshold error correction both fall with increasing distance between the markets in question. The effect of 1000 km of additional distance is between -10.8 and -13.8% in all specifications and thus appears to be estimated robustly. However, distance has no significant effect on the likelihood of threshold error correction. Contiguity has a positive effect of 16.8% on the probability of linear cointegration and of 17.3% on the probability of threshold cointegration. When the air-line distance is included in the estimation, the effect of contiguity on the likelihood of linear cointegration becomes insignificant. This is presumably due to the collinearity between distance and contiguity. A common language has as expected a positive effect on linear cointegration (25.0%) and to a smaller extent also on threshold cointegration (11.1%). The inclusion of airline-distance into the equation does not change the magnitude of this effect.

Overall, linear cointegration is more prevalent when markets are closer in terms of geographical distance, linguistic and historical proximity. Threshold cointegration and geographical distance exhibit no statistically robust relationship, but border and language variables affect its likelihood in the sample.

5. Discussion

Generally the previously formulated hypothesis is supported by the evidence. Proximity does matter for whether rice prices in spatially separated markets are linearly or threshold cointegrated. The results are clear and statistically significant. This is the case although statistical testing naturally involves type I and type II errors resulting in false assignment of the observations to the three specified groups.

Some further caveats of the study are to be mentioned. The presence of multicollinearity of some of the variables is a noteworthy issue. We expect language to increase price transmission ceteris paribus but in the region, language is correlated with distance. Geographically proximate countries are more likely to be linguistically proximate. This makes it hard to separate their effects. Moreover, few data for West African countries are available thus limiting the number of countries in our study. Extending the analysis to a world-wide data set similar to the scope of gravity trade studies could be a worthwhile endeavor in the future. Typical for price transmission studies is the potential selection bias arising from limited data availability. Small or isolated markets are less likely to be included in big international data sets. We expect that these markets are also systematically less likely to be cointegrated with other markets. The data sets come from countries that participate in these international market information systems, generally countries with better infrastructure and institutions. Distance will presumably have a smaller effect on trade and price transmission in such countries.

Future research could study the effect of distance on the speed of price adjustment. Moreover, one could include an additional variable for policies. Countries that employ difference rice market policy tools are less likely to be characterized by rice price co-movement. Two countries that impose a tariff at their borders will have rice prices that move in parallel, but if one country uses a tariff and the other an import quota, their prices will be less likely to co-move. Future studies could also take a closer look at the difference of the border effects for neighboring countries and countries that do not share a common border.

6. References

Aker, J., Klein, M., Connell, S., & Yang, M. (2013). Borders, Ethnicity and Trade. *Tufts University Working Paper Series*, 1–72.

Anderson, J., & Van Wincoop, E. (2004). Trade costs. *Journal of Economic Literature*, *42*(3), 691–751.

Demont, M., Rutsaert, P., Ndour, M., & Verbeke, W. (2013). Reversing Urban Bias in African Rice Markets: Evidence from Senegal. *World Development*, *45*, 63–74.

Demont, M., Rutsaert, P., Ndour, M., Verbeke, W., Seck, P., & Tollens, E. (2012). Experimental auctions, collective induction and choice shift: willingness-to-pay for rice quality in Senegal. *European Review of Agricultural Economics*, *40*, 1–26.

Dickey, D., & Fuller, W. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association*, *74*(366), 427–431.

Engel, C., & Rogers, J. (1995). How wide is the border? *International Finance Discussion Papers*, *498*, 1–40.

Fackler, P. L., & Goodwin, B. K. (2001). Spatial price analysis. *Handbook of Agricultural Economics*, *Volume 1*, 971–1024.

Gonzalo, J., & Pitarakis, J.-Y. (2006). Threshold Effects in Cointegrating Relationships. *Oxford Bulletin of Economics and Statistics*, *68*, 813–833.

Greb, F., von Cramon-Taubadel, S., Krivobokova, T., & Munk, A. (2013). The estimation of threshold models in price transmission analysis. *American Journal of Agricultural Economics*, *95*(4), 900–916.

Hansen, B., & Seo, B. (2002). Testing for two-regime threshold cointegration in vector error-correction models. *Journal of Econometrics*, *110*(2), 293–318.

Hernandez-Villafuerte, K. (2011). The relationship between spatial integration and geographical distance in Brazil. *Annual Meeting of the European Association of Agricultural Economics (EAAE), Zürich, Switzerland*, 1–37.

Jensen, R. (2007). The digital provide: Information (technology), market performance, and welfare in the South Indian fisheries sector. *The Quarterly Journal of Economics*, *CXXII (3)*, 879–924.

Johansen, S. (1988). Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control*, *12*, 231–254.

Larsen, B. (2012). A threshold cointegration analysis of Norwegian interest rates. *Master's Thesis in Statistics, University of Tromso.*, 1–141.

Mayer, T., & Zignago, S. (2011). Notes on CEPII's distances measures: The GeoDist database. *CEPII Working Paper Series*, *25*, 1–24.

Mengel, C., & von Cramon-Taubadel, S. (2014). Distance and border effects on price transmission - a meta-analysis. *GlobalFood Discussion Papers*.

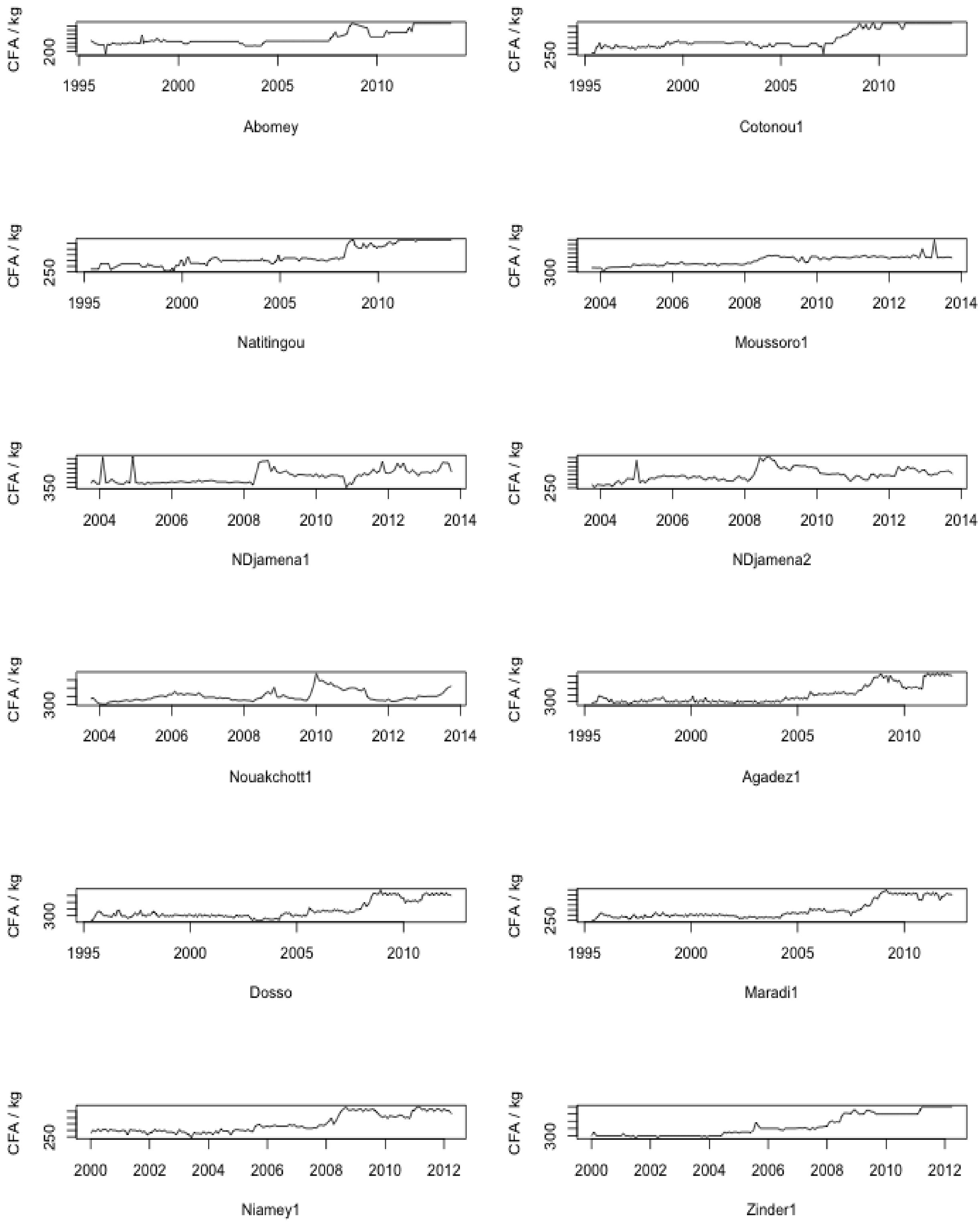
Seo, M. (2006). Bootstrap testing for the null of no cointegration in a threshold vector error correction model. *Journal of Econometrics*, *134*(1), 129–150.

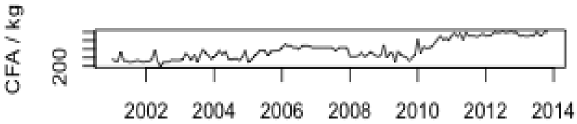
Stephens, E., Mabaya, E., von Cramon-Taubadel, S., & Barrett, C. (2012). Spatial Price Adjustment with and without Trade. *Oxford Bulletin of Economics and Statistics*, *74*(3), 453–469.

Zannou, A. (2010). Determinants of intra-ECOWAS trade flows. *African Journal of Business Management*, *4*, 678–686.

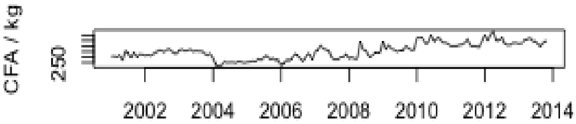
7. Appendix

Figure 1: Plots of price series

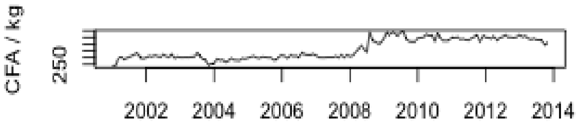




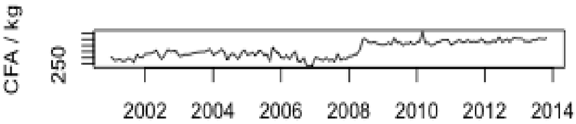
Amegnran



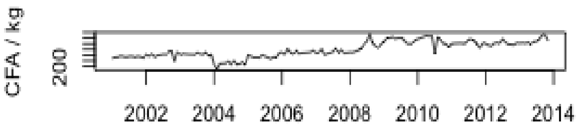
Anie



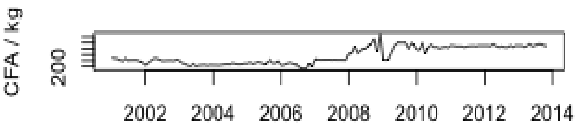
Cinkasse



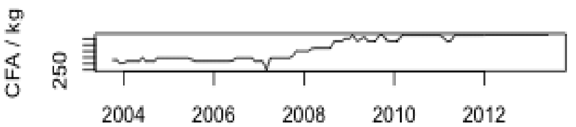
Kara



Korbongou

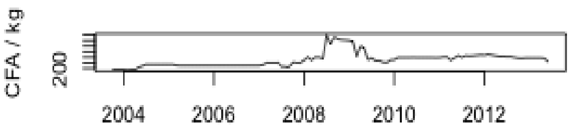


Lome

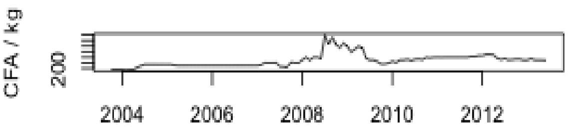


Cotonou2

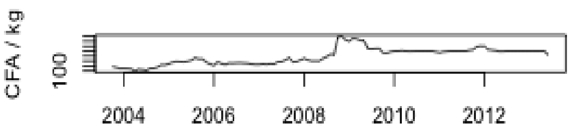
Abidjan



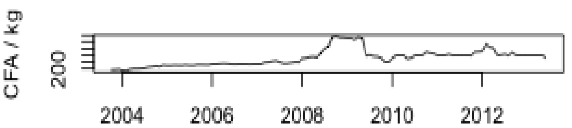
Dakar



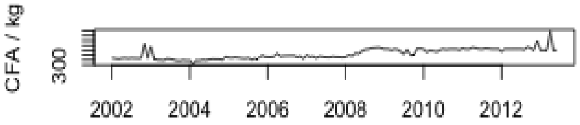
Kaolack



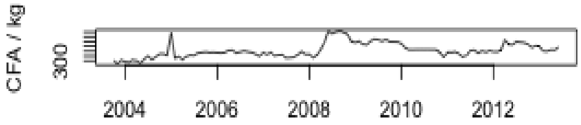
StLouis



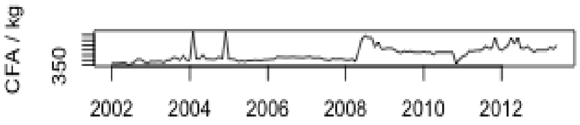
Ziguinchor



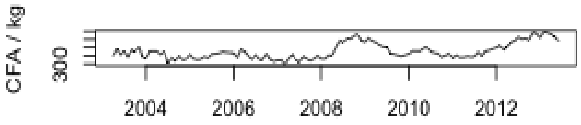
Moussoro2



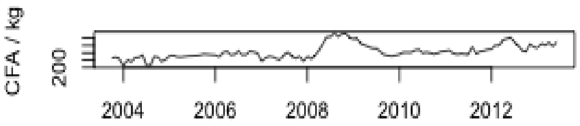
NDjamena3



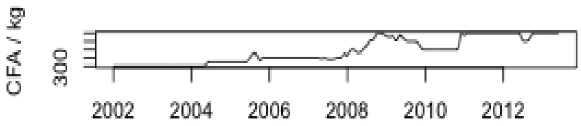
NDjamena4



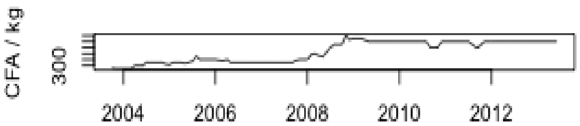
Noukchott2



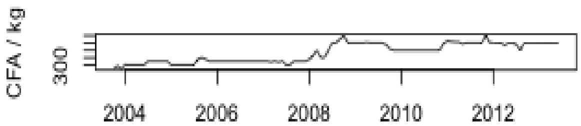
Noukchott3



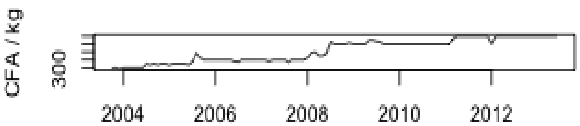
Agadez2



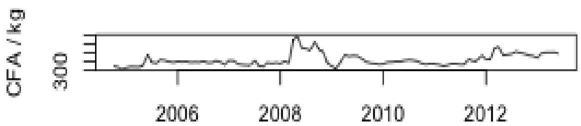
Maradi2



Niamey2



Zinder2



Bodjia