

Asymmetry in Transaction Costs and Price Transmission: The Case of Cowpea Market in Burkina Faso

Apollinaire R. Nikiema¹ and Takeshi Sakurai^{1*}

We use a TVECM to analyze the nature of price relationship and adjustment between local markets of cowpea in Burkina Faso. First, the estimated thresholds suggest that not only transaction costs between central market and secondary markets are asymmetric but also higher for producing markets. Second, the sign and the amplitude of adjustment parameters are consistent with the spatial equilibrium even if prices respond quickly to positive shocks than negative shocks. Finally, the distribution of observations across different trade regimes suggests that markets are well performing in the sense that they display fewer violations of competitive spatial equilibrium.

Key words: price transmission, transaction cost, threshold vector error correction model (TVECM)

1. Introduction

Price transmission is used to assess the nature of price relationship and the direction of causal relationship between agricultural prices in surplus and deficit locations. According to Barrett and Li (2002), spatial price transmission can be defined as the process by which demand, supply and transaction costs in spatially separated markets jointly determine prices and trade flows, as well as the transmission of price shocks from one market to another.

Indeed, an efficient price transmission mechanism is important to promote food security and agricultural development. The lack of spatial price transmission is often associated with food insecurity due to the fact that there is no connection between markets. In addition, poor spatial transmission of prices can convey inappropriate information in the price system leading to incorrect production and marketing decisions. As a result, agricultural producers fail to specialize in the long term based on comparative advantages and gains from trade will not be realized (Baulch, 1997).

Several factors are listed in the literature to explain low price transmission in the developing countries: the market power of some intermediaries (Abdulai, 2000), the oligopolistic behavior, the asymmetric information (von Cramon-Taubadel and Meyer, 2004), intervention policies (Krivonos, 2004), transaction costs (Goodwin and Piggott, 2001), and market structure and security (Wu *et al.*, 2019).

Although this study is in line with the existing literature,

instead of identifying the factors causing low price transmission, this study focuses on reversible trade flow and analyzes its implication on market efficiency, particularly on the asymmetry in price transmission. The reversible trade flow is often observed in developing countries, where rural households are sellers of a specific crop during harvest time but most of them become buyers of the same product during the lean season. This situation makes trade flows reversible between central urban market and secondary markets.

The contributions of this study are twofold. First, although the reversible trade flows are common in developing countries including Burkina Faso and have influences on food security of rural as well as urban poor population, they are not well investigated in the context of price transmission. This study will be one the few studies to the authors' best knowledge. Second, as oppose to previous studies in developing countries, we use the regularized Bayesian estimator to estimate a threshold vector error correction model (TVECM) with three regimes, which allows us not only to distinguish between price transmission and spatial competitive equilibrium but also to study price transmission in a context with reversible trade flows.

This analysis focuses on cowpea not only because of its significant contribution to household food security and income in Burkina Faso¹), but also because it is the most typical crop with which we can observe the reversible flows. As a subsistence crop, cowpea has been known to be an

¹ The University of Tokyo
Corresponding author*: atsakura@mail.ecc.u-tokyo.ac.jp

1) Cowpea is produced by over 1.2 million farmers in almost everywhere in the country with about 19 million population.

Production is very unstable as it depends on variable rainfall and variable planted area. The plot size varies from 0.25 to 12 hectare and the yield per hectare is 700kg on average (MASA, 2013)

important source of cheap protein to combat protein deficiencies in rural areas (Langyintuo *et al.*, 2003). It is a cheap protein source for urban consumers as well. Because of the rapidly growing urban population and the development of transportation infrastructures, a significant amount of cowpea is sold in the urban markets: 50% of cowpea produced was sold and income generated from this sale accounted for 5.8% of agricultural income in 2010 (MASA, 2013). Export is also increasing due to growing demand in neighboring countries: from 5,421 Mt in 2005 to 19,500 Mt in 2010 (MASA, 2013). Thus, cowpea has now become an important cash crop. Although many subsistence crops are sold for cash to some extent, cowpea's dual nature is prominent. As a result, the reversible trade flow is a significant characteristic in cowpea market in Burkina Faso.

The marketing system of cowpea in Burkina Faso presents as a spider's web with converging and diverging connections depending on the level of marketing considered. The starting signal is given by farmers according to the maturity of their crops and their financial needs; and the circuit is piloted by wholesalers located in major urban centers. The latter deploy their network to rural areas to collect cowpea and other products through the intervention of collectors who play an important role in the marketing channel²⁾. These large traders store the products in their warehouses and then redeploy their network for sale either to the country's deficit areas or for export to neighboring countries (Figure 1).

2. Methods

1) Theoretical framework

The spatial price transmission analysis is based on the Law of One Price (LOP). The LOP stipulates that in an efficient market an identical good must have the same price at every point in that market. The LOP is maintained between geographically separated markets through spatial arbitrage. Any price difference between two markets of an identical good will create an arbitrage rent in the absence of transaction costs. This rent will motivate merchants to transfer the product from the low-price market to the high-price market until the rent is eliminated and prices equalize again.

To take into account the transaction cost between a pair of trading regions the LOP is reformulated as a spatial equilibrium model (Judge and Takayama, 1971) and can be

summarized as follows:

$$p_t^i - p_t^j \leq \psi_{j \rightarrow i} \quad (1)$$

where p_t^i is the price of good in the deficit market i and p_t^j is the price in surplus market j at time t and $\psi_{j \rightarrow i}$ is cost of trade from market j to market i . The spatial equilibrium model stipulates that the prices of a given good at two locations should not differ by no more than the transaction costs of trading the good between these locations. Otherwise traders will engage in spatial arbitrage, which increases the price at the low price market and reduces the price in the high price market until the spatial equilibrium $p_t^i - p_t^j = \psi_{j \rightarrow i}$ be restored.

However, another very likely case is that the prices in these two markets vary freely in the interval $[p_t^j - \psi_{j \rightarrow i}; p_t^i + \psi_{i \rightarrow j}]$. The existence of such an interval is called a "neutral band". Based on the LOP and the existence of hidden transaction costs, studies such as Lo and Zivot (2001) have shown that arbitrage is only profitable outside the band of transaction costs around the prices of a good in two markets.

2) Empirical specification

Following Greb *et al.* (2014), we specify a TEVCM with three regimes that models price relationship between a central market c (capital city market) and secondary markets s (collecting markets, assembling markets (local wholesale), and retail markets) as follow:

$$\left. \begin{aligned} \Delta p_t^c &= \theta_i^c + \rho_i^c(p_{t-1}^s - p_{t-1}^c) + \sum_{m=1}^M \beta_{im}^c p_{t-m}^c + \varepsilon_{it}^c \\ \Delta p_t^s &= \theta_i^s + \rho_i^s(p_{t-1}^s - p_{t-1}^c) + \sum_{m=1}^M \beta_{im}^s p_{t-m}^s + \varepsilon_{it}^s \end{aligned} \right\} \text{(regime } i)$$

$$i = 1, 2, 3$$

if $p_{t-1}^s - p_{t-1}^c \leq \psi_1$, then regime 1

if $\psi_1 < p_{t-1}^s - p_{t-1}^c \leq \psi_2$, then regime 2, and

if $\psi_2 < p_{t-1}^s - p_{t-1}^c$, then regime 3 (2)

where $\Delta p_t = p_t - p_{t-1}$ and $t = 1, \dots, n$. θ, ρ, β and ψ are the parameters to be estimated. All parameters in the three regimes simultaneously estimated by the regularized Bayesian estimating method. The parameters of greatest interest are ρ and ψ . We take price at level and then interpret the error correction term as the transaction cost in the same monetary unit as the price.

The ρ are the adjustment parameters³⁾ that measure how quickly a deviation from the equilibrium relationship is

2) Only 19.3% cowpea stocks held by wholesalers come directly from producers, while 40.4% from semi-wholesalers, and 40.3% from other wholesalers respectively (DGPFR, 2012).

3) For example, ρ_k^s measures the speed of adjustment of secondary market.

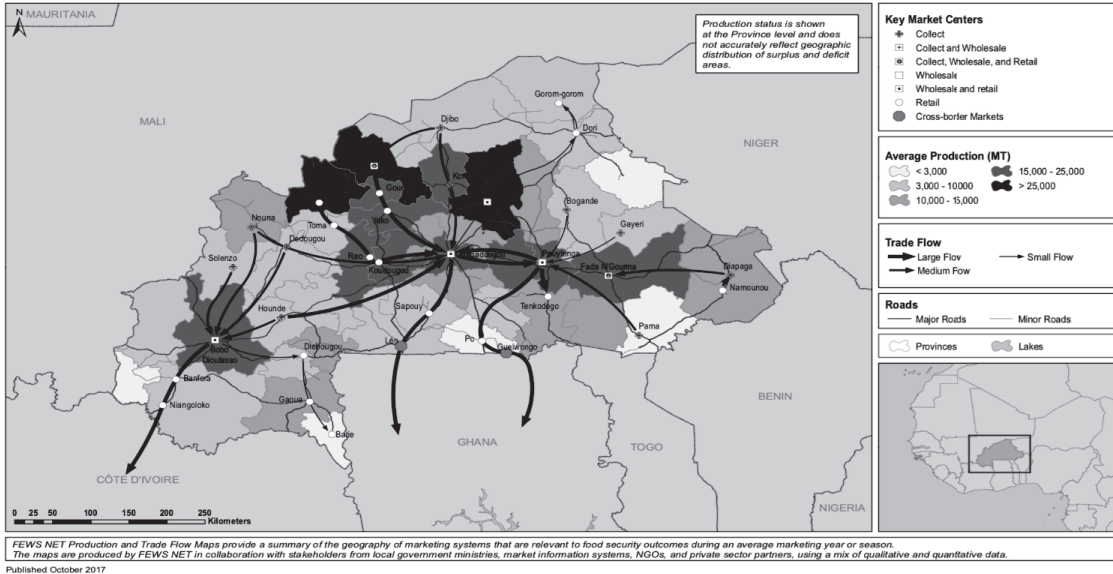


Figure 1. Production and trade flow map of cowpea in Burkina Faso (FEWS NET, 2017)

corrected by changes in p^C and p^S . The stability condition for cointegration is given by $|1 - (\rho_k^S - \rho_k^C)| \leq 1$ such that deviations from the long-run equilibrium are corrected and specifically, for the outer regimes $k = 1$ and $k = 3$. However, as discussed in Greb *et al.* (2014), when price deviates from an equilibrium in the context of spatial arbitrage, trade restores an equilibrium by causing the higher price to fall and the lower price to rise. Hence it is reasonable to expect $\rho_k^S \leq 0$, $\rho_k^C \geq 0$ and $0 < (|\rho_k^S| + \rho_k^C) \leq 1$.

To sum up we expect: (i) in regime 2, ρ to be zero or not significantly different from zero, since in accordance with the competitive spatial equilibrium, no correction is required; and (ii) in regimes 1 and 3, ρ to be significantly different from zero and the total adjustment to be higher than in regime 2 as they are violations of the competitive spatial equilibrium and then should trigger arbitrage and price adjustments to restore equilibrium.

The ψ are the thresholds value and are interpreted as the estimated transaction cost. Data on transaction costs are rarely available, especially in developing countries. The estimation of threshold parameters in TVECMs is typically performed using profile likelihood method (Hansen and Seo, 2002) and computed using a grid search (Goodwin and Piggott, 2001).

However, Greb *et al.* (2013) shows that the profile likelihood estimation produces biased estimates, particularly for a small sample. The high number of the parameters in

TVECM combined with the need to set trimming parameter is the sources of bias. They proposed a regularized Bayesian estimator that penalizes differences between regimes so as to minimize differences when the data contain little information. As a consequence of this regularization, the posterior density is well-defined over the entire range of the threshold parameters, which eliminates the need to choose an arbitrary trimming parameter and produces estimates with less bias than the profile likelihood method. Thus, we make the use of regularized Bayesian estimator in this analysis.

We adapt the strategy employed by Jamora and von Cramon-Taubadel (2016). First, we evaluate null hypothesis of linear cointegration against threshold for threshold cointegration using the test proposed by Hansen and Seo (2002). Second, we estimate the TVECM in equation (2) for each pair of markets using the regularized Bayesian estimator adopting the R code provided by Greb *et al.* (2013).

3. Data and Results

1) Data

This study uses monthly price data across 44 local markets collected from 07/2004 to 08/2018 by the Grain Market Information System (SIM) of Burkina Faso. In these markets three types of prices are collected: farm gate price, retail price, and wholesale price. For this study, the market of the capital city Ouagadougou is chosen as the central market. A recent survey supports that Ouagadougou traders detain more than

Table 1. Estimation results of TVECM with Ouagadougou as the central market¹

Market Type	N	Regime 1				Regime 2				Regime 3			
		ρ_1^S	ρ_1^C	$\sum \rho_1$	ψ_1	ρ_2^S	ρ_2^C	$\sum \rho_2$	ψ_2	ρ_3^S	ρ_3^C	$\sum \rho_3$	
Producer	18	-0.10	0.26	0.36	-82.75	-0.08	0.13	0.21	40.35	-0.55	0.07	0.62	
(collecting)		(89)	(94)	(0.20)		(11)	(28)	(0.77)		(89)	(50)	(0.03)	
Wholesale	6	-0.10	0.28	0.38	-63.71	-0.01	0.12	0.13	31.65	-0.55	0.21	0.76	
(assembling)		(83)	(100)	(0.29)		(00)	(00)	(0.70)		(100)	(100)	(0.01)	
Consumer	19	-0.08	0.34	0.42	-64.67	-0.13	0.17	0.30	34.50	-0.61	0.08	0.70	
(retail)		(68)	(78)	(0.16)		(00)	(00)	(0.81)		(100)	(73)	(0.03)	
All	43	-0.09	0.29	0.38	-70.38	-0.07	0.14	0.21	35.50	-0.57	0.12	0.69	
				(0.21)				(0.76)				(0.03)	

Note: The numbers are the average of estimated parameters of each pair of market for each market type. In the case of All, the average parameters of each market type are averaged using the number of price series as weight. N= number of price series. Distribution of observations across trade regimes is in bold parentheses and percentage of pair of market with significant parameters in simple parentheses.

70% of national cowpea stocks (MASA/SONAGESS, 2016). In the central market, main operating agents are retailers and wholesalers but only retailer price is available.

2) Results

When checking price series properties⁴⁾, it comes out that most of the price series are integrated (I1) and the Hansen and Seo (2002) test identifies 31 over 43 of markets displaying threshold cointegration with the central market. The results of the econometric estimation are shown in Table 1. It shows the average of estimates of the thresholds and the adjustment parameters across trade regimes and different types of market.

We begin with the estimated thresholds (ψ). First, transaction cost is higher for collecting markets. For example, the estimated threshold for collecting markets is 82.75 FCFA/kg for lower bound and 40.35 FCFA/kg for the upper bound⁵⁾. One possible explanation of these results is the high transportation cost between the capital city and producing localities not only because the majority of collecting markets are located in remote regions as compare to other types of market but also because the quality of transportation infrastructure is lower.

Second, the estimated thresholds are asymmetric. That is, the per unit transactions cost depend on the trade flow direction. Although this analysis does not consider seasonal change of the transaction cost, since the trade flow has seasonality, we can assume that the transaction cost also has seasonality. On average, the unit transaction cost from

secondary to the central market is 70.38 FCFA/kg while it costs only 35.50 FCFA/kg to transfer cowpea from the central market to the other markets. A rational for the asymmetry in transaction cost may be the presence of the economies of scale as well as the economies of scope in favor to cereal traders as they own larger transportation capacities carrying cowpea with other commodities when operating compare to rural farmers or collectors who handle small quantities individually. The lower transaction cost from the central markets to rural markets may make the reversible trade flow possible.

Finally, the “neutral band” is [-70.38; 35.50] implying that price deviations within this interval does not triggers arbitrage between deficit and surplus market as trade is not profitable. Moreover, the distribution of observations across different regimes suggests that more than 76% of observations fall under regime 2. This may suggest that these markets are well performing in the sense that they display fewer violations of spatial equilibrium (Baulch, 1997). However, since the size of neutral band is quite large compared with the average price of cowpea (320 FCFA/kg in the central market and 270 FCFA/kg in the secondary markets) the observed fewer violations may be owing to the high transaction cost. Because trade volume is not included in our analysis, the conclusion that the cowpea markets perform well should be taken with precaution.

Now we turn to the speed of adjustment (ρ). First, the signs and the amplitudes of estimated adjustment rates are consistent

4) These results are not presented here in the interest of brevity but available from the authors upon request.

5) FCFA stands for franc de la Communauté financière africaine, the

currency of francophone West Africa. The exchange rate with Euro is fixed at 1 € = 655,957 FCFA since 1999.

Table 2. Determinants of estimated thresholds and adjustment parameters¹

Explanatory variables	(1) Lower bound	(2) Upper bound	(3) Total adjustment in Regime 1	(4) Total adjustment in Regime 3
Log of distance	8.15**	16.76***	-0.15**	-0.09*
Border market (1/0)	-6.57	-0.18	0.11	0.01
Collecting market (1/0)	18.9***	5.58	-0.17**	-0.43
Number of observations	205	205	205	205
R^2	0.05	0.07	0.07	0.02

Note: We consider two majors urban city markets and 3 major assembling markets as central markets in equation 2. **, and *** indicate significance level at 5%, and 1%. We regress these estimates from 205 ((44-5) * 5+5*2) pairs of markets on the explanatory variables in the first column.

with the prediction of spatial equilibrium model across different types of market and regimes. For example, in regime 1, when a shock causes price difference to be lower than the lower threshold, on average, prices in other markets will fall by 9% and price in the central market will increase by 29% given a total adjustment of 38% per month until the equilibrium be restored. This is true for all price relationship between the central market and secondary markets. Also, a high percentage of significant ρ_i^c suggests that shock from secondary market affect prices in the central market.

Moreover, adjustment parameters in regime 2 is lower than their counterparts in regime 1 and in regime 3. For example, for all samples total adjustment rates are 38% and 69% in regime 1 and in regime 3 respectively while it is only 25% in regime 2. However, we found that adjustment parameters are significant for some pairs of markets in regime 2, specifically for collecting markets. This is not predicted by the spatial equilibrium model. This result may be explained by the fact that collecting markets are relative small and located further and hence may be only connected to the central market through trade with neighboring markets (Jamora and von Cramon-Taubadel, 2016).

Second, adjustment speed is asymmetric. That is, prices response more quickly to positive shocks than negative shocks. For example, on average a positive shock (regime 3) causes total adjustment of 69% per month while total adjustment is only 38% for a negative shock in the same market (regime 1). That is 5 weeks 5 days are required for one-half negative deviation from the equilibrium to be eliminated while only 2 weeks 2 days is necessary for positive deviation. This result is consistent with asymmetry in transaction cost discussed above. This finding supports the results of previous studies in developing countries. However, the extent of price transmission between domestic markets seems to be higher when using TVECM with three regimes.

To examine the effect of transportation on the transaction

costs and price adjustments, we regress the estimated thresholds and adjustment parameters on the log of the distance. We include dummy variables for border and collecting markets. Market is considered as a border market when it is located in a commune that shares border with a neighboring country. Since the dependent variables in these regressions are estimates, we follow Lewis and Linzer (2005)'s recommendation and compute heteroskedastic consistent standard errors in the regression analysis.

The results are shown in Table 2. First, we find that the estimated thresholds are positively and significantly associated with the distance (columns 1 and 2) and as a result, a lower price adjustment between markets (columns 3 and 4). These results are expected as the distance captures the transportation cost that is a major component of transaction costs in most developing countries like Burkina Faso.

Second, we find that collecting markets are associated with higher transaction cost and lower price transmission. But this result is significant for only trade in regime 1. This result is consistent with TVECM results that emphasize higher transaction costs for trade between collecting and central market.

Finally, border does not have a significant effect on threshold values and adjustment parameters. This result is not expected as one may assume that markets located at the border are likely to be affected by border trade. One explanation is that even if border markets are closer to neighboring consumers than the central market in Burkina Faso, there is not a close big market in neighboring countries that can affect significantly prices in these markets.

4. Conclusion

In this study, we use TVECM to model price relationship of cowpea in the presence of transaction cost, focusing on reversible trade flow between rural markets and the central

market.

We find the following. First, the results suggest that transaction costs depend on the direction of trade flow and this asymmetry is larger for trade between rural markets and the central market. Second, the signs and the amplitudes of the price adjustments are consistent with the spatial equilibrium model even though prices response more quickly when central market price falls than when it increases. Also, market seems to perform well as they display fewer violation of spatial equilibrium. Third, lower price transmission seems to be associated with longer distance between markets suggesting that transportation cost is limiting cowpea market performance in Burkina Faso.

Overall, although the cowpea market seems to perform well as they display fewer violation of spatial equilibrium, high transaction costs due to long-distance transportation is still a constraint for rural producing locations to connect to the central market.

One limitation of our analysis is that we only consider price and not trade flows although our interest is on the reversible trade flow. This is common limitation of price transmission literature as trade data are rarely available in developing countries, especially in high frequency.

Acknowledgement

Part of data collection of this study is financially supported by Japan International Research Center for Agricultural Sciences (JIRCAS).

References

- Abdulai, A. (2000) Spatial Price Transmission and Asymmetry in the Ghanaian Maize Market, *Journal of Development Economics* 63(2): 327–349. [https://doi.org/10.1016/S0304-3878\(00\)00115-2](https://doi.org/10.1016/S0304-3878(00)00115-2).
- Barrett, C. B. and J. R. Li (2002) Distinguishing between Equilibrium and Integration in Spatial Price Analysis, *American Journal of Agricultural Economics* 84(2): 292–307. <https://doi.org/10.1111/1467-8276.00298>.
- Baulch, B. (1997) Transfer Costs, Spatial Arbitrage and Testing for Food Market Integration, *Agricultural & Applied Economics Association Transfer* 79(2): 477–487.
- DGPER (Direction Generale de la Promotion de l'Economie Rurale) (2012) *Enquete sur la Commercialisation des Produits Agricoles*.
- FEWS NET (Famine Early Warning System Network) (2017) Production and Trade Flow Map, Cowpea, Normal Year. <http://fews.net/west-africa/burkina-faso/production-and-trade-flow-map/october-2017>.
- Goodwin, B. K. and N. E. Piggott (2001) Spatial Market Integration in the Presence of Threshold Effects, *American Journal of Agricultural Economics* 83(2): 302–317. <https://doi.org/10.1111/0002-9092.00157>.
- Greb, F., S. von Cramon-Taubadel, T. Krivobokova, and A. Munk (2013) The Estimation of Threshold Models in Price Transmission Analysis, *American Journal of Agricultural Economics* 95(4): 900–916. <https://doi.org/10.1093/ajae/aat006>.
- Greb, F., T. Krivobokova, A. Munk, and S. von Cramon-Taubadel (2014) Regularized Bayesian Estimation of Generalized Threshold Regression Models, *Bayesian Analysis* 9(1): 171–196. <https://doi.org/10.1214/13-BA850>.
- Hansen, B. E. and B. Seo (2002) Testing for Two-Regime Threshold Cointegration in Vector Error-Correction Models, *Journal of Econometrics* 110(2): 293–318. [https://doi.org/10.1016/S0304-4076\(02\)00097-0](https://doi.org/10.1016/S0304-4076(02)00097-0).
- Jamora, N. and S. von Cramon-Taubadel (2016) Transaction Cost Thresholds in International Rice Markets, *Journal of Agricultural Economics* 67(2): 292–307. <https://doi.org/10.1111/1477-9552.12152>.
- Judge, G. and T. Takayama (1971) Spatial and Temporal Price Allocation Models, *Journal of International Economics* 3(3): 304. [https://doi.org/10.1016/0022-1996\(73\)90024-X](https://doi.org/10.1016/0022-1996(73)90024-X).
- Krivosos, E. (2004) *The Impact of Coffee Market Reforms on Producer Prices and Price Transmission*. <https://doi.org/10.1596/1813-9450-3358>.
- Langyintuo, A. S., J. Lowenberg-DeBoer, M. Faye, D. Lambert, G. Ibro, B. Moussa, A. Kergna, S. Kushwaha, S. Musa, and G. Ntougam (2003) Cowpea supply and demand in West and Central Africa, *Field Crops Research* 82(2–3): 215–231. [https://doi.org/10.1016/S0378-4290\(03\)00039-X](https://doi.org/10.1016/S0378-4290(03)00039-X).
- Lo, M. and E. Zivot (2001) Threshold Cointegration and Nonlinear Adjustment to the Law of One Price, *Macroeconomic Dynamics* 5: 533–576.
- MASA (Ministere de l'Agriculture et de la securite Alimentaire) (2013) *Rapport Final Situation de Référence Filières Agricoles*.
- MASA/SONAGESS (Ministere de l'Agriculture et de la securite Alimentaire/Societe National de la Gestion des Stocks de Securite alimentaire) (2016) *Etude pour l'Etablissement d'une Situation de Stocks Institutionnels au Burkina Faso*.
- von Cramon-Taubadel, S. and R. J. Meyer (2004) Asymmetric Price Transmission: A Survey, *Journal of Agricultural Economics* 55(3): 581–611.
- Wu, W., H. Chien, T. Sakurai, and S. Muranaka (2019) Vertical Price Transmission in the Nigerian Cowpea Market, *British Food Journal*. <https://doi.org/10.1108/BFJ-09-2018-0591>.