Journal of Agriculture and Rural Development in the Tropics and Subtropics
Vol. 116 No. 2 (2015) 213–226

urn:nbn:de:hebis:34-2015111149311 ISSN: 2363-6033 (online); 1612-9830 (print) – website: www.jarts.info

How do domestic policies affect the integration of Ethiopian fertiliser markets with world markets?

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Abstract

Frequent shifts in policy on fertiliser markets have occurred in Ethiopia with the aim of facilitating both physical and economic access of farmers to fertiliser. The last shift was the introduction of a monopoly on each stage of the supply chain in 2008. Furthermore, government control of prices and margins as well as stockholding programmes are also present on the markets. This paper evaluates the effect of these policies on the integration of domestic with world markets of fertiliser, using cointegration methods. Time series data of diammonium phosphate (DAP) and urea prices on world, import and retail markets between 1971 and 2012 are used. The findings show high transmission of price signals from world markets to import prices for both DAP and urea. However, between import and retail prices there is no evidence of cointegration for urea, while for DAP full price transmission is concluded. In the retail market, domestic transaction costs associated with storing large volumes of fertiliser act as a buffer between import and retail prices, especially for urea. Therefore, economic benefits could be achieved by reducing the size of stocks and revising the demand estimation process.

Keywords: agricultural policy, Ethiopia, fertiliser use, price transmission, vector error correction models

1 Introduction

Low agricultural productivity is one of the main development challenges in sub-Saharan Africa and particularly in Ethiopia (Abebaw & Haile, 2013). Although various measures are required to enhance agricultural productivity, a great potential lies in increasing fertiliser use. The current use of fertiliser in Ethiopia is only 17 kg/ha of nutrients (Spielman *et al.*, 2011) compared to the global average of 173 kg/ha (Hernandez & Torero, 2011). The low fertiliser use is inadequate to replenish the nutrients removed by harvested crops (Yamano & Kijima, 2010). An increased and appropriate use of fertiliser is expected to increase crop productivity and profitability of smallholder farming, while being environmentally friendly (Vanlauwe *et al.*, 2014). The apparent role that increased fertiliser use can play in improving agricultural productivity has motivated the federal government of Ethiopia (FGov) to implement various policies in fertiliser markets.

Following the introduction of mineral fertiliser to the country in 1967, a state monopoly prevailed in fertiliser markets until the fall of the central planning regime in 1991 (Matsumoto & Yamano, 2011). The following years witnessed the market liberalisation with private dealers controlling a significant share of the market (Spielman *et al.*, 2010). Between 1996 and 2000,

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Published online: November 26, 2015

companies owned by regional governments came into play, as the regional governments believed that the private dealers were not able to facilitate access of farmers in remote areas to fertiliser. Due to high subsidies involved in keeping these companies afloat, there was a policy shift towards channelling fertiliser through agricultural cooperatives (Rashid *et al.*, 2013). Thus, from 2006 onwards, cooperatives became the dominant actors in fertiliser markets (Zerfu & Larson, 2010). However, in 2008, the FGov decided to coordinate all fertiliser imports through one company in order to take advantage of economies of scale (Kumar, 2011). Subsequently, one importer is selected each year. Since the introduction of the policy, the Agricultural Inputs Supply Enterprise (AISE), a government company, has been awarded this position every year. This arrangement reduced the role of the cooperatives to fertiliser distribution (Rashid *et al.*, 2013). In addition to the *de facto* monopoly created on each stage of the chain, fertiliser credit to poor farmers and stockholding programmes were also in place alongside with state control of prices and marketing margins for fertiliser dealers.

Despite the various policy shifts that occurred, the use of fertiliser remains low in Ethiopia. Two types of fertiliser are mostly used in the country: diammonium phosphate (DAP) and urea. These products are entirely imported. The major cause of low fertiliser use in Ethiopia is the high price (Dercon & Christiaensen, 2011). The retail prices of fertiliser products in Ethiopia are two to threefold the prices on world markets (Gregory & Bumb, 2006). To better understand the determinants of the high price gap, a price transmission analysis is presented in this study to assess the extent to which fertiliser markets in Ethiopia are integrated with world markets. Furthermore, the study analyses the effect of current policies on the intensity of transmission of price signals from world to domestic markets.

2 Literature review

The previous market integration and price transmission studies in Ethiopia have focused on food and cash crops. Minot (2011) and Berweck (2010) analysed vertical price transmission from world to domestic markets for cereals during the episodes of high prices on world markets in 2007/08. Conforti (2004), Getnet (2008), Rashid (2011) and Jaleta & Gebremedhin (2012) evaluated spatial price transmission for various cereals. Worako *et al.* (2008) analysed the impact of reforms of the coffee marketing system in Ethiopia, while Alemu & Worako (2011) analysed price transmission asymmetry and market power exertion along the marketing system of coffee in Ethiopia.

Unlike the agricultural outputs, agricultural inputs have received little attention in terms of price transmission studies. In Ethiopia, no price transmission study has been found on fertiliser. In South-Africa, Alemu *et al.* (2011) observed incomplete price transmission from world to domestic markets for four types of fertiliser (DAP, muriate of potassium, ammonia and urea). They found asymmetric price transmission and concluded that most of the price gap is due to non-policy factors such as poor infrastructure and the presence of market power in the fertiliser market. In Asia, Dawe (2009) showed that transmission for urea prices from the world markets between 2003 and 2007 was high in the Philippines and Vietnam, but low in Bangladesh, where domestic price stabilisation policies prevented the pass-through. However, one weakness of that study is its reliance on basic calculation of cumulative changes in international and domestic prices in real terms. Thus, no inference could be drawn about the long-run equilibrium between world and domestic markets of urea.

There is no study addressing market integration and price transmission for agricultural inputs in Ethiopia. This research gap is addressed by this paper. The supply chain of fertiliser is analysed; the price gap and the intensity of price transmission in the long-run from world markets to domestic prices in Ethiopia are investigated. Finally, the effect of the various domestic policies on market integration with world markets of fertiliser is analysed.

3 Methods and data

3.1 Methods

The approach applied consists of three main methods: supply chain analysis, price gap assessment and price transmission analysis. The supply chain analysis aims at describing the chain, the actors involved and their interactions. The information needed to understand the structure of the supply chain of fertiliser was collected through literature research and key informant interviews with farmers, farmer cooperatives, the AISE, the Ethiopian Ministry of Agriculture (MoA), the Bureaus of Agriculture (BoA), the Ethiopian Cooperative Promotion Agency, the Ethiopian Agricultural Transformation Agency, the Ethiopian Development Research Institute (EDRI) and the International Food Policy Research Institute (IFPRI).

The price gap is assessed in three steps. First, it is calculated as the difference between import and world market prices. In this sense, it covers the international freight, insurance costs and land transportation from Djibouti port to central warehouses in Ethiopia. Second, the price gap between retail and import prices is computed and includes domestic marketing costs and other transaction costs incurred after fertiliser has reached the country. Finally, the overall price gap between retail and world market prices is calculated. This total price gap encompasses all transaction and marketing costs incurred along the fertiliser supply chain.

For the price transmission analysis, dynamic regression models are used, as they allow for the time lag inherent to transporting goods (Fackler & Goodwin, 2001). It takes about six months between the procurement of fertiliser on international markets and its delivery to the users in Ethiopia. More specifically, cointegration methods are used as they are able to account for the non-stationarity characteristic of most time series of price data (Amikuzuno & von Cramon-Taubadel, 2012). The analysis consists of five main steps. First, the unit root test checks whether individual price times series are non-stationary and integrated of order one. For this purpose, the Augmented Dickey-Fuller (ADF) test is applied. Second, the Johansen-Trace test is run in order to check for the presence of long-run equilibrium between pairs of time series. Third, the Granger causality test is conducted and aims at identifying the lead-lag relationships between two markets. This test detects the direction of price transmission, while the vector error correction models (VECM) needed to inform on the intensity of price transmission are estimated in the fourth step.

The VECM examine both the long-run equilibrium and the short-run dynamics of the joint behaviour of two time series of price data that are cointegrated of order one. For two markets A (market of destination) and B (market of origin), the VECM representation of price transmission is as follows:

$$\begin{bmatrix} \Delta p_t^A \\ \Delta p_t^B \end{bmatrix} = \gamma + \begin{bmatrix} \alpha^A \\ \alpha^B \end{bmatrix} ect_{t-1} + \sum_d \Gamma_d \begin{bmatrix} \Delta p_{t-d}^A \\ \Delta p_{t-d}^B \end{bmatrix} + \begin{bmatrix} u_t^A \\ u_t^B \end{bmatrix} \quad (1)$$

where p_t^i is the (log) price on market i at time t and Δ is the operator for the first difference between prices in current and previous periods. γ is a (2×1) vector of constants. Constants are added to the regression as prices usually do not fluctuate around zero mean. Each Γ_d is a (2×2) matrix of coefficients relating current and past price changes; d is the number of lags included in the model. In the model specification, d is chosen according to Hannan-Quinn or Final Prediction Error selection criteria. u_t^A and u_t^B are the error terms with zero mean. α^A and α^B are the adjustment coefficients, which measure the responses of p_t^A and p_t^B to the error correction term (ect_{t-1}). ect_{t-1} measures deviations from the long-run relationship between p_t^A and p_t^B and can be written as follows:

$$ect_{t-1} = p_{t-1}^A - (\beta_0 + \beta_1 * p_{t-1}^B) \quad (2)$$

where β_0 stands for the margin between markets A and B. β_1 is the elasticity of price transmission from market B to A. It shows the share of any shock occurring on market B that is transmitted to A. When β_1 equals 1, price signals fully transmit from B to A. Assuming $\beta_1^* = -\beta_1$ and $\beta_0^* = -\beta_0$, and inserting equation (2) into (1), gives:

$$\begin{bmatrix} \Delta p_t^A \\ \Delta p_t^B \end{bmatrix} = \gamma + \begin{bmatrix} \alpha^A \\ \alpha^B \end{bmatrix} \left[\begin{bmatrix} 1 & \beta_1^* \end{bmatrix} \begin{bmatrix} p_{t-1}^A \\ p_{t-1}^B \end{bmatrix} + \beta_0^* \right] \quad (3)$$

$$+ \sum_d \Gamma_d \begin{bmatrix} \Delta p_{t-d}^A \\ \Delta p_{t-d}^B \end{bmatrix} + \begin{bmatrix} u_t^A \\ u_t^B \end{bmatrix}$$

In the remaining part of this paper, markets A and B are referred to as world, import and retail markets of fertiliser. Finally, a residual analysis is performed on the error terms u_t^i to ensure that the estimated VECM is valid. The Portmanteau test is used to check for autocorrelation, Multivariate Auto-Regressive Conditional Heteroskedastic Lagrange Multipliers (ARCH LM) for heteroscedasticity and Jarque-Bera test for normality. While, residual autocorrelation indicates a major model defect, non-normal residual distribution and remaining heteroskedasticity in residual series may not be a big problem (Lütkepohl, 2004a,b).

All tests are performed in JMulTi 4.24 software. A time trend is included in the model specification when there is evidence of significant trend in the data series. The VECM is first specified with the Johansen one stage procedure. If full price transmission cannot be rejected by a Wald test, the VECM is re-specified with restrictions in order to exclude non-significant coefficients. Thus, the model is estimated in a two-stage procedure, with the S2S procedure in the first stage and the GLS procedure in the second stage. The critical value for all tests performed is chosen at the 5 % significance level.

3.2 Data

The time series data used for the analysis emanate from the annual prices of world, import and retail markets from 1971 to 2012. Annual prices were considered because the structure of the fertiliser markets is such that the retail price is fixed, once for a whole year by the MoA. Although price transmission studies using annual data cannot capture adjustments processes that occur within days or weeks, they are a good indication of price transmission at their level of temporal aggregation. When a certain degree of price transmission is found in low-frequency data such as annual data, issues that affect price transmission in the short term, such as costs of search can be ruled out (Miller & Hayenga, 2001). Then, attention should focus on explanations based on inventory management practices that respond only to low frequency price changes (Meyer & von Cramon-Taubadel, 2004).

Free on board (f.o.b.) prices at the main export ports are collected from the World Bank commodity price database (World Bank, 2014) as world market prices. As import price, the cost insurance and freight (c.i.f.) price is used, which is the price after the delivery of fertiliser to the central warehouses in Ethiopia. In the database of the MoA and AISE, data entries for import prices up to 2001 are in c.i.f. prices, while between 2002 and 2012, they are in cost and freight (c.f.r.) price. The c.f.r. price is the price at the Djibouti port. The difference between the c.i.f. and the c.f.r. prices is largely composed of the land transportation and the insurance between Djibouti port and the central warehouses in Ethiopia. Therefore, data points between 2002 and 2012 were adjusted to have all import prices in c.i.f. equivalent prices. Retail prices in this study are average prices from different retail centres. Import prices were derived from the AISE archives (AISE, 2013), while retail prices were assessed from the EDRI database (EDRI, 2013) and from primary cooperatives' books (PC, 2013).

For the price transmission analysis, all time series data are logarithmised, so that the estimated coefficients can be interpreted as price transmission elasticities. All prices are converted to US dollar per metric ton (USD/MT). Prices originally in Ethiopian local currency (Ethiopian birr) are converted, using the official exchange rate published by the EDRI and the National Bank of Ethiopia. One missing data point in the times series of import prices for both DAP and urea was filled by interpolation with the average of the adjacent values. Unlike the time series data of world markets and retail prices that start in 1971, data on import prices are available only from 1985 onwards. In the time series of retail prices for urea, seven data points are missing between 2003 and 2012. For some of them, both adjacent values are missing. Hence, the interpolation procedure cannot be applied. Therefore, it was decided to truncate the time series at 2002 to avoid including many computed data in the time series. As a result, the length of the times series used in this study is 28 annual observations for DAP and 18 for urea.

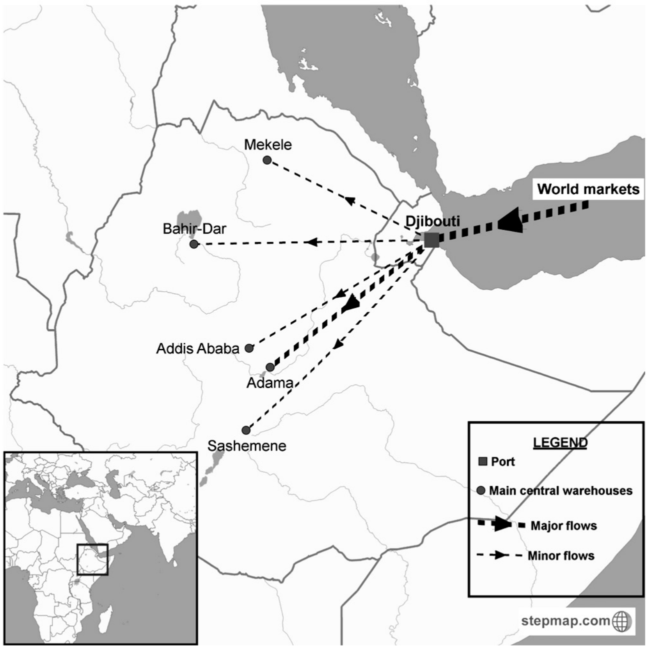
4 Results

4.1 The fertiliser marketing chain

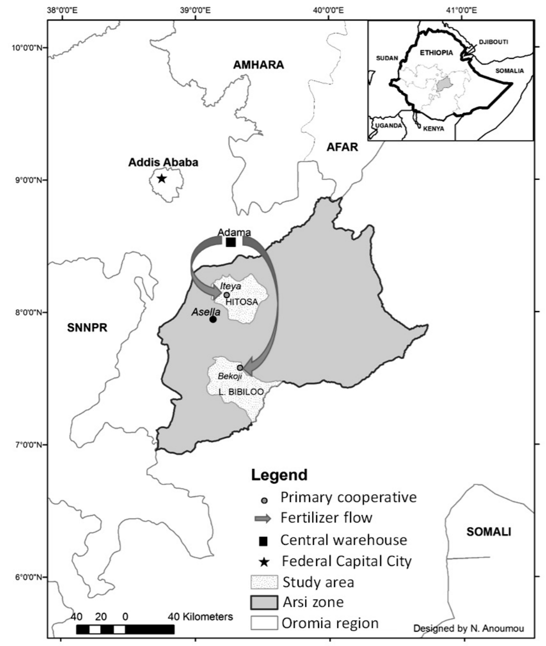
There are four main functions along the supply chain of fertiliser in Ethiopia: import planning and inventory control, import execution, marketing and distribution, and final use. The import planning consists in assessing the demand before the procurement. It is a bottom-up approach through which farmers' demand is collected by extension workers and is progressively aggregated at district, zone and region levels by the respective Bureaus of Agriculture (BoA). The final aggregation occurs at the national level by the Agricultural Inputs Marketing Directorate of the Ministry of Agriculture (AIMD/MoA). However, in practice, many manipulations occur in the process. Some extension workers do not collect farmers' demand and instead report their own estimates. For this reason, BoA officers are reluctant to use these estimates. Moreover, BoA officers assume that with the sustained extension effort, farmers will use more fertiliser than the figures reported by the extension workers. Subsequently, they make assumptions over fertiliser rates farmers would apply to estimate the fertiliser demand. After aggregation at the national level and consideration of stocks in central warehouses, the import schedule is prepared by the AIMD.

Import execution is implemented by the sole importer, AISE. International suppliers are invited through a competitive tendering process. Winning suppliers are selected by an inter-ministerial committee. As Ethiopia is a landlocked country, ports of neighbouring countries are used. The nearest ports are Djibouti and Assab (Eritrea). However, due to political conflict with Eritrea, the main port for Ethiopian imports is Djibouti. International suppliers deliver the fertiliser to Djibouti port under the supervision of AISE, which conducts the customs clearing. From the port, AISE transports the supplies to central warehouses with large capacity inside Ethiopia. The following warehouses are considered for the main agricultural regions of the country: Adama and Sashemene for the Southern region, Adama and Bahir Dar for the Amhara Region (North-West), Addis Ababa, Adama, Mojo and Debre Zeit for the Oromia region (Centre) and Mekele for the Tigray region (North-East) (see Figure 1a [1]). Fertiliser distribution is conducted by

[1] Mojo, and Debre Zeit were not represented in Figure 1 for clarity reasons because they are very close to Addis Ababa and Adama



a. *Flow from world markets to central warehouses*



b. *Flow from central warehouses to primary cooperatives (PC)*

Fig. 1: *Map of fertiliser flow in Ethiopia*
Source: Own illustration

agricultural cooperatives. Cooperative unions (CUs) operate at district (*woreda*) level. They receive their quotas of fertiliser from the MoA and the BoAs at the central warehouses. Although they keep part of their supply in their own warehouses, most of it is directly transported from the central warehouses to primary cooperatives (PCs). Each CU is mandated to supply all PCs in its coverage area with specific quotas assigned by the MoA and the BoAs. PCs cover one or several sub-districts (*kebele*). The transporters are selected based on a tender floating process conducted by the zonal BoAs on behalf of the CUs. This intervention of the zonal BoA is necessitated by the lack of skills of CU managers in dealing with such a process. The flow of fertiliser from the central warehouses to the PCs is depicted in Figure 1b. This figure shows the flow in the Arsi zone, which belongs to the Oromia region, where two districts were sampled for this study. Each of these districts is covered by a CU (Hitosa CU for Hitosa district and Gaalamaa CU for L. Bilbiloo district). Within each district, one PC is illustrated.

The CUs as well as the PCs are supplied with fertiliser on credit, which is guaranteed by the regional governments' budgets. This credit is based at the Commercial Bank of Ethiopia, a government bank, which settles a letter of credit to pay the international suppliers and the AISE. The PCs, after receiving their quotas, make the fertiliser available to farmers at a fixed retail price, which is a weighted average of the new supply's price and the price of the old stock. The new supply price is made up of the initial c.f.r. price, transportation costs, loading and unloading costs, warehouse rental costs, spillage and inventory costs, and marketing margins for AISE, CUs and PCs. Some cost items like the marketing margins, loading, bagging, and spillage costs are set by the MoA and the BoAs. The marketing margins in 2013 for instance were set at 0.84 USD/MT for AISE, 3.09 USD/MT for CUs and 5.05 USD/MT for PCs. Other cost items such as transportation between Djibouti port are taken from the service providers and their average is computed at the regional level. As fertiliser is supplied to the cooperatives on credit, they are charged 9.5 % nominal interest rate to be reimbursed with the credit capital within 6 months. The old stock price includes the storage costs and the initial price of the fertiliser purchased in the previous year. Because the government is implementing fertiliser stockholding programmes, stocks in some years are large and their costs significantly influence the final weighted average retail price. Transportation costs from central warehouses to each PC are added to the weighted price computed at the regional level so as to arrive at the final retail price at each PC.

Smallholder farmers are the main users of fertiliser products in Ethiopia. They purchase exclusively from the PCs, since private retailers are not authorized to sell fertiliser anymore and illegal trade is punishable by imprisonment. Since 2011, most farmers purchase fertiliser on cash basis. However, in very remote and poor areas, there is a programme to provide farmers with fertiliser on credit. Most farmers use DAP, but only a few use urea. In the Arsi zone, for instance, the farmer survey conducted for this study showed that all farmers use DAP, but only 25 % of them use urea. Figure 2 illustrates the supply chain of fertiliser in Ethiopia. The actors operating each chain function are represented below the respective function. The main tasks performed by each actor in connection with the chain function are briefly described below each actor.

4.2 Price gap analysis

The total price gap is higher for urea than for DAP (Table 1). The world market price makes up about two thirds of the retail price for DAP, while for urea, it only makes up one third of the retail price. The costs associated with the domestic transactions form about half of the retail price of urea, while they are only one sixth of the retail price of DAP. This difference is first related to the fact that urea is less consumed by farmers and this often results in large left-over stocks. Hence, the storage costs significantly increase its domestic costs. Additionally, cost items such as internal transportation, marketing margins and warehouse rental that are the same in absolute terms for urea and DAP, are higher for urea if expressed as a proportion of the retail price, since the retail price of urea is lower than that of DAP.

Most of the domestic costs are associated with the transportation of fertiliser, interest payments and the storage costs. Marketing margins received by the cooperatives are only a small fraction of the price gap. The marketing margins are set by the MoA at break-even costs assuming that cooperatives aim at helping farmers and do not seek profit. Similarly, the marketing margins for the AISE are also set at the break-even cost by the MoA, assuming that the AISE as a government company does not seek profit. Altogether, the marketing margins received by the AISE and the cooperatives made up 3.2 % of the total price gap for DAP and 3.9 % of the total price gap of urea in 2012.

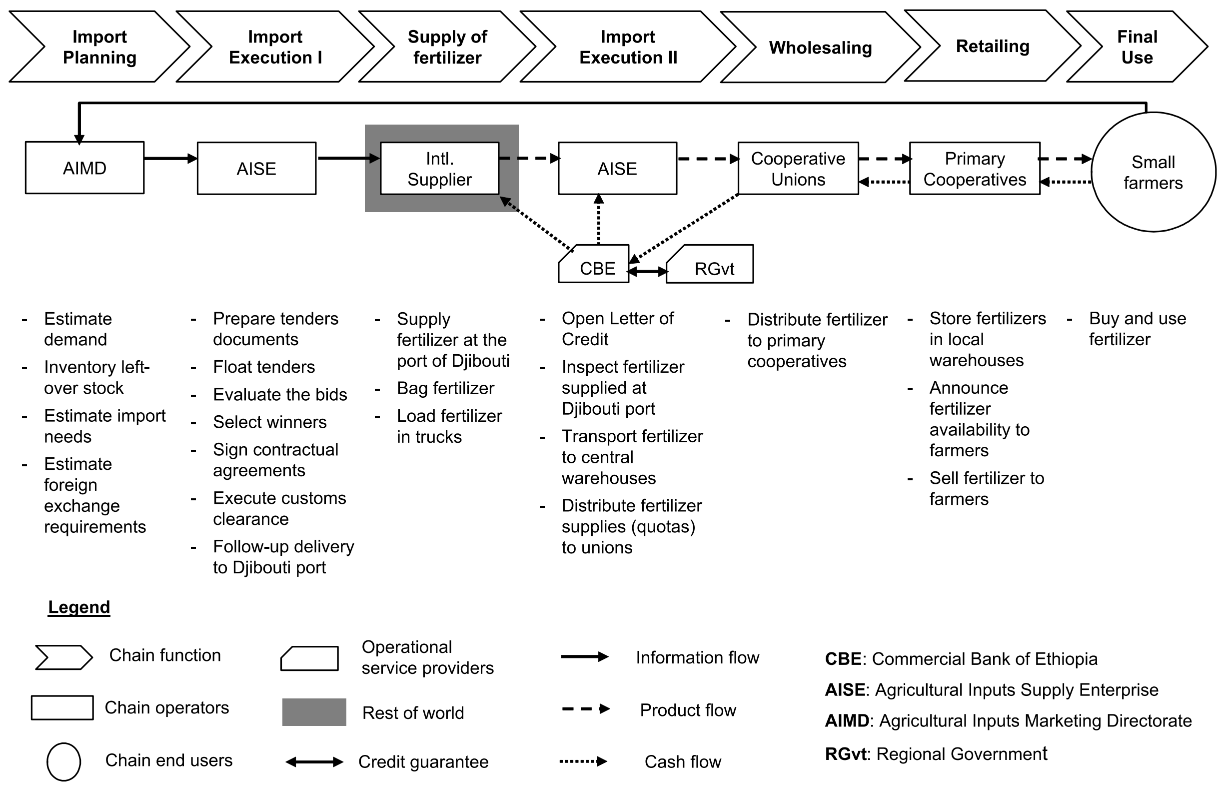


Fig. 2: *Fertiliser supply chain functions in Ethiopia*
Source: Own illustration

Table 1: *Price gap summary, average prices from 1971 to 2012*

	DAP	*Urea*
Average world market price (WP) in USD/MT	264.92	110.09
Average import price (IP) in USD/MT	347.38	150.59
Average retail price (RP) in USD/MT	410.21	294.18
Average total price gap (TPG = RP-WP) in USD/MT	145.28	184.09
Average international transaction costs (IT= IP-WP) in USD/MT	82.45	40.50
Average domestic transaction costs (DT=RP-IP) in USD/MT	62.83	143.59
DT as share of RP	15.3 %	48.8 %
IT as share of RP	20.1 %	13.8 %
WP as share of RP	64.6 %	37.4 %

Source: Own calculations based on World Bank (2014), AISE (2013), EDRI (2013), PC (2013).

4.3 Price transmission analysis

Time series data for world market, import and retail prices of DAP and urea are depicted in Figure 3. In Figure 3a, there is a noticeable peak in 2007/08 followed by another one of lower magnitude in 2011. These peaks show that the surge in world market prices observed in these periods for a large range of commodities also occurred on fertiliser markets. As shown by the graphs, price volatility on world markets affects both import and retail prices. However, it can be observed in Figure 3a that the magnitude of the peaks and troughs between 2006 and 2009 on the world markets was more pronounced than on the domestic markets. This suggests that some price stabilisation policies were implemented on the domestic markets.

The ADF test (Table 2) shows that each time series is non-stationary and integrated of order one. The null hypothesis of non-stationarity fails to be rejected in the level data but is rejected in the first differences.

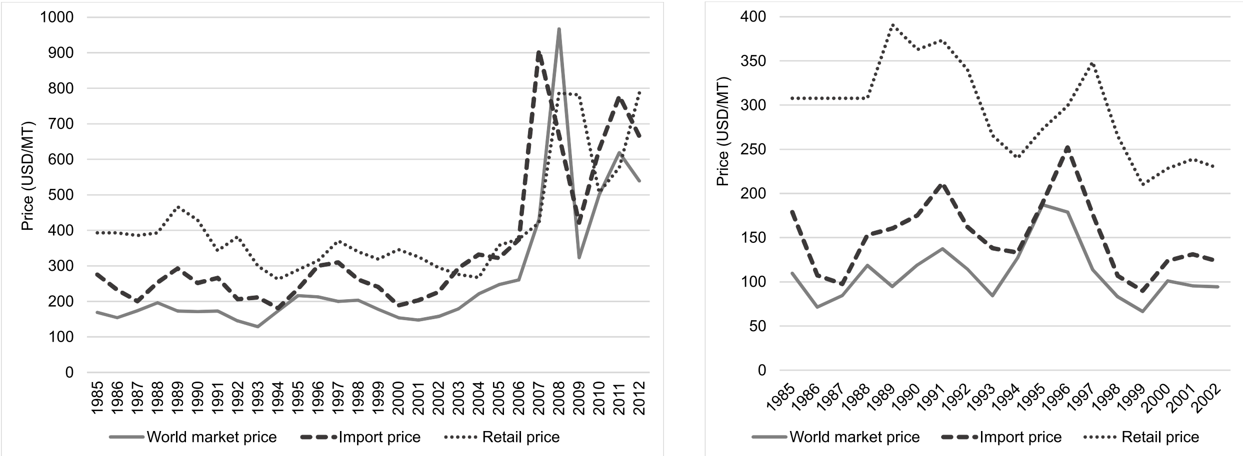
Results of the Johansen trace test (Table 3) suggest that for DAP, all pairs of time series of prices have one cointegrating vector. However, for urea, only pairs of world market and import prices as well as world market and retail prices are found to be cointegrated. No evidence for cointegration between import and retail prices could be found and therefore, this market pair is excluded from further analyses.

For DAP, the Granger causality test (Table 4) points out unidirectional lead-lag relation from import to retail price and from import to world market price. The results also indicate an overall unidirectional lead-lag relation from world market to retail prices. For urea, the results suggest that the import price leads the world market price, which leads the retail price.

More detailed information on the price transmission intensity is provided by the VECM analysis. For DAP (Table 5), the VECM results suggest an incomplete price transmission from the world market to the import price. The adjustment coefficient α^{import} being not significantly different from zero suggests that the import price does not react to deviations from the long-run equilibrium. Counterintuitively, α^{world} is significantly different from zero, implying that the world market price reacts to deviations from the long-run equilibrium. The value of β_0 indicates the presence of a long-run margin between world market and import prices. Assuming a world market price of 100 USD/MT, this would result in an import price of 151 USD/MT ($e^{0.97} * (100)^{0.88} = 151$).

Between import and retail prices, the VECM results indicate perfect price transmission, with only the retail price of DAP reacting to changes in the long-run price equilibrium. The value of β_0 implies a long-run margin between import and retail prices of 34 % of the import price. The overall transmission from the world market to the retail price is complete. The coefficient α^{retail} is significantly different from zero implying that the retail price of DAP reacts to deviations from the long-run price equilibrium, while the world market price does not react. The value of β_0 implies a long-run margin of 88 % of the world market price.

For urea, the results of the VECM show that the null hypothesis of full price transmission from world market to import prices is rejected. Only α^{world} is significantly different from zero, implying that the world market price reacts to deviation from the long-run equilibrium. The value of β_0 suggests the presence of a long run margin. Assuming a world market price of 100 USD/MT, this would cause an import price of 135 USD/MT. Fur-



a. *DAP* **b.** *Urea*

Fig. 3: *World market, import and retail prices*
Source: World Bank (2014), AISE (2013), EDRI (2013), PC (2013)

Table 2: *ADF test for time series of DAP and urea prices.*

Commodity	*Time series data*	*Level data*		*First differences*	
		Number of lags	*Value of t-statistic*	*Number of lags*	*Value of t-statistic*
DAP	World market price	0	–2.60	1	–6.00 *
	Import price	2	–0.14	1	–5.72 *
	Retail price	3	–1.87	2	–3.15 *
Urea	World market price	2	–2.41	1	–6.06 *
	Import price	3	–0.73	1	–5.12 *
	Retail price	1	–2.47	1	–4.19 *

Source: Own calculations based on World Bank (2014), AISE (2013), EDRI (2013), PC (2013).
Critical values for the ADF test are: –2.57 (10 %), –2.86 (5 %) and –3.43 (1 %).
Number of lags selected according to Hannan-Quinn Criterion
* Rejection of H_0 of non-stationarity at 5 % level of significance.

Table 3: *Johansen-Trace test for DAP and urea prices.*

Pairs of time series	*DAP*			*Urea*		
	Number of lags	*Null hypothesis*	*p-Value of trace test*	*Number of lags*	*Null hypothesis*	*p-Value of trace test*
World market and import prices	8	$r0=0$	0.00 *	8	$r0=0$	0.03 *
		$r0\leq1$	0.08		$r0\leq1$	0.21
Import and retail prices	8	$r0=0$	0.00 *	3	$r0=0$	0.13
		$r0\leq1$	0.35		$r0\leq1$	–
World market and retail prices	1	$r0=0$	0.00 *	10	$r0=0$	0.00 *
		$r0\leq1$	0.24		$r0\leq1$	0.44

Source: Own calculations based on World Bank (2014), AISE (2013), EDRI (2013), PC (2013).
Number of lags selected according to Hannan-Quinn criterion
* Rejection of H_0 of no cointegration at 5 % level of significance.

Table 4: *Granger causality test results for DAP and urea prices.*

Null hypothesis	*p-Value of F-stat.* DAP	*p-Value of F-stat.* Urea
World price does not Granger cause import price	0.45	0.19
Import price does not Granger cause world price	0.00 *	0.00 *
Import price does not Granger cause retail price	0.00 *	–
Retail price does not Granger cause import price	0.14	–
World price does not Granger cause retail price	0.00 *	0.00 *
Retail price does not Granger cause world price	0.33	0.32

Source: Own calculations based on World Bank (2014), AISE (2013), EDRI (2013), PC (2013).
Number of lags selected according to Hannan-Quinn criterion
* Rejection of H_0 at 5 % level of significance.

Table 5: *Restricted VECM coefficients for DAP and urea prices.*

	Pairs of time series	*Number of lags*	*Adjustment coefficients*			*Transmission elasticity*	*Long-run margin*
			α^{world}	α^{import}	α^{retail}	β_1	β_0
DAP	World market and import prices	2^{FPE}	1.12 *	–0.69		0.88	0.97
	Import and retail prices	6^{FPE}		–1.27	–0.49 *	1.00	0.29
	Retail and world market prices	1^{HQ}	0.00		–0.21 *	1.00	0.63
Urea	World market and import prices	8^{FPE}	2.25 *	0.00		1.18	–0.53
	Retail and world market prices	4^{FPE}	0.00		–0.50 *	0.28	4.40

Source: Own calculations based on World Bank (2014), AISE (2013), EDRI (2013), PC (2013).
^{HQ} Number of lags selected according to Hannan-Quinn criterion
^{FPE} Number of lags selected according to Final Prediction Error criterion when the number of lags suggested by HQ criterion is too large to allow the model to run.
* Rejection of H_0 of α=0 at 5 % level of significance.

Table 6: *Results of VECM checking for pairs of prices of DAP and urea.*

	Pairs of time series	*p-Value of Portmanteau Test*	*p-Value of Jarque-Bera test*		*p-Value Multivariate ARCHLM test*
			u_1	u_2	
DAP	World market and import prices	0.99	0.00 *	0.56	0.51
	Import and retail prices	0.96	0.91	0.38	0.35
	Retail and world market prices	0.99	0.78	0.00 *	0.02 *
Urea	World market and import prices	0.96	0.53	0.75	0.35
	Retail and world market prices	0.98	0.77	0.38	0.17

Source: Own calculations based on World Bank (2014), AISE (2013), EDRI (2013), PC (2013).
* Rejection of H_0 at 5 % level of significance.

thermore, the hypothesis of full price transmission from world market to retail price has to be rejected. Nonetheless, α^{retail} is significantly different from zero, suggesting that the retail price reacts to changes in the long-run equilibrium. Assuming a world market price of 100 USD/MT, the value of β_0 suggests a retail price of 296 USD/MT.

The residual analysis for the two models (Table 6) shows non-normality and heteroskedasticity problems being partially present in the first and the third model estimated for DAP. However, since no autocorrelation problem is found in any of the models, all estimated VECM are considered to be overall valid.

5 Discussion

The overall price gap between world and retail prices shows that the retail price of urea is almost threefold its world market price, while the retail price of DAP is about 1.5 times its world market price. The long-run margins estimated by the VECM suggest a similar price gap in the case of urea, and a larger one for DAP, for which the retail price is estimated to be about twofold the world market price. In general, these findings are in line with the results of Gregory & Bumb (2006), who found that the retail prices of fertiliser in Ethiopia were two to threefold the world market price levels. The price gap analysis also indicates that the world market price is the largest component of the retail price for DAP and the second largest for urea. Marketing margins received by the importer and the distributors of fertiliser make up a small fraction of the total price gap. These findings suggest that fertiliser prices in Ethiopia are competitive. They compare favourably with prices in other East African countries such as Kenya, Uganda, Rwanda and Tanzania (Rashid *et al.*, 2013). According to Heisey & Norton (2007), domestic costs associated with fertiliser in Ethiopia are comparable with those found in other African countries, though higher than those observed in Asian and Latin American countries.

The study shows that a price hike on international and Ethiopian fertiliser markets occurred during the food price crisis of 2007/08. The driving factor for this surge in fertiliser prices on world markets was the rise in energy prices (Headey & Fan, 2008). Because fertiliser production is highly energy-intensive, fertiliser prices roughly quadrupled during the crisis. The finding that the magnitude of the price change was higher on world markets than on domestic markets can be attributed to the implementation of various price stabilisation policies by the FGov. First, on the onset of the crisis, the government put in place a tariff exemption on fertiliser in addition to the existing indirect import subsidies that were allocated to the CUs through the credit lines guaranteed by the regional governments. In case of payment default, the regional governments were prompted to fill the gap. Another measure enacted by the FGov after the price spike of 2007 was the sole importer policy described in section 1. Despite the *de facto* monopoly created on the import market, this measure enabled the government to exercise a greater control over price and quantity of imported fertiliser. This government control contributed to limit the pass-through of price shocks from world to domestic markets.

On the retail market, the magnitude of the price spike and the shape of the retail price curve can be understood in light of price stabilisation and fertiliser subsidy policies implemented by the government. First, the government released its buffer stocks in order to stabilise fertiliser prices. Second, like for imports, there were also indirect subsidies on the retail market. Fertiliser was distributed to farmers on credit guaranteed by the government budget. In case of default, the regional governments would make up for the loss. The fact that the magnitude of the shock was higher on the world market than on the import and the retail markets suggests that the policies implemented by the government were effective to some extent. However, to gain deeper insights into this, one would need high frequency time series and a sufficient number of observations in order to include a structural break in the price transmission model. Such analyses conducted in Bolivia and Vietnam showed however that policies aiming at preventing the transmission of the price shock from world to domestic markets during the 2007/08 price spike were mostly ineffective for both imported and exported commodities (Luckmann *et al.*, 2014; Schüttel *et al.*, 2011).

For DAP, the Granger causality test for the model estimated between world market and import prices suggests that the world market price reacts to the import price. This counterintuitive result is confirmed by a visual observation of Figure 3a, which shows that the import price peaks before the world market price. It is also confirmed by the adjustment coefficients estimated in the VECM analysis, which indicate that only the world market price reacts to deviations from the long-run equilibrium. These results are the opposite of what one would expect. According to by Gregory & Bumb (2006), the total fertiliser market in all sub-Saharan African countries represents less than 1 % of the global fertiliser market. Thus Ethiopia, which constitutes only a fraction of this market share is too small a player to influence world market prices. However, two explanations can be provided. First, the results could be interpreted in light of the structure of the Ethiopian fertiliser markets. Indeed, the import price reflects international suppliers' expectations about future world market prices. When bidding prices in response to the tenders floated usually in August by the AISE and the AIMD, the international suppliers try to anticipate prices that would prevail at the delivery time in January-February of the next year. Thus, when prices started to soar on world markets, international suppliers immediately and exorbitantly raised their prices. This anticipation mechanism could explain the rejection of the hypothesis of full price transmission from world market to import prices, as the expectations do not completely match the real price development. The second explanation is that the data may be flawed. The data used in this study may suffer from inconsistency because they were taken from different sources, mostly unpublished reports.

The result of the Granger causality test between import and retail prices is in line with expectations and shows that the import price leads the retail price. This result is confirmed by the VECM analysis, which shows that only the retail price reacts to changes from the long-run equilibrium. The model indicates full price transmission from import to retail prices. Thus, the domestic policies do not hinder the cointegration of domestic and world markets of DAP. Finally, the retail price follows the world market price, as expected. Only the retail price reacts to deviations from the long-run equilibrium. Price signals are fully transmitted from world market to retail prices. Thus, a good overall integration of domestic markets with world markets for DAP is concluded.

For urea, the Johansen-Trace test shows no evidence of cointegration between import and retail prices, indicating that there is no long-run equilibrium between these prices. The absence of a long-run equilibrium can be interpreted in light of the fertiliser demand process and farmers' demand for urea. In fact, the demand estimation process, which assumes that farmers apply fertiliser according to the recommended application rates, has often overestimated the demand for urea. In contrast to DAP, the application of urea is optional for most farmers as their soils are sufficient in nitrogen. Thus, they do not buy as much urea as planned by officers in charge of demand estimation. As a result, there are large left-over stocks of urea. The current demand estimation procedure based on official targets instead of actual demand and the monopoly in supply do not provide incentives to the actors to improve the management of inventories. Moreover, only stocks at central warehouses are taken into account when estimating the final procurement needs, while left-over stocks at PC and CU level even exceed stocks at central warehouse level. Storage costs related to these stocks strongly influence the retail price for urea. Subsequently, there is a fluctuating price margin associated with the stocks that keeps the retail price disconnected from the import price.

The Granger causality test between world market and import prices for urea shows that the world market price follows the import price. The transmission elasticity is found to be 1.18, which means that a price change on international markets is amplified domestically. As for DAP, these results could be interpreted by the anticipation mechanism of future prices on world markets or by the flaw in the data. The Granger causality test also shows that the world market price leads the retail price of urea, as one would expect. The hypothesis of perfect price transmission is rejected. The large stocks of urea, which keep the retail price disconnected from the import price also explain the absence of perfect price transmission from the world market to retail prices. In contrast to the case of South Africa (Alemu *et al.*, 2011), this study shows that for urea, policy factors play a significant role in the price gap and the pass-through of price shocks in Ethiopia.

State intervention in fertiliser markets and especially in urea markets in Ethiopia comes at a cost for both farmers and the government. Farmers have to pay high retail prices because of the bad management of inventories. For the government, Rashid *et al.* (2013) showed that fertiliser promotion involved about US$ 40 million per year as fiscal costs since 2008 (the year of policy shift towards more state control). Therefore, policy options should seek ways to optimize stocks, reduce government intervention in the markets and improve the supply chain.

6 Conclusion

This study shows that government policy plays an important role on fertiliser markets in Ethiopia. Between world markets and import prices, the high transmission observed suggests that the procurement of fertiliser on international markets in Ethiopia is competitive and that domestic markets on the import side are well integrated with world markets. However, between import and retail prices, government policy led to a mixed result. While for DAP perfect price transmission from import to retail price is observed, there is no evidence of cointegration between import and retail prices for urea. In the case of DAP, the estimated demand often matches the actual demand, as farmers use it intensively. Thus, stocks are kept at acceptable levels and do not prevent the transmission of price signals from import to retail prices.

However, in case of urea, which is less intensively used by farmers, the mismatch between estimated and actual demand has resulted in the accumulation of large stocks. The biased demand estimation procedure based on assumptions instead of farmers' need, combined with the state of monopoly that does not provide incentives for an efficient inventory management lead to high storage costs that are translated into the retail price in the following year. This keeps the retail price disconnected from the new import price.

In light of these results, different policy options could improve fertiliser markets in Ethiopia. The first option is to improve the demand estimation procedure. First, inventories at central warehouses as well as at cooperative level should to be incorporated into the final procurement need estimation. Moreover, the stockholding programme needs to be revised so as to minimize stocks, especially for urea. Additionally, transparency and trust should be enhanced along the demand estimation process. Extension workers in charge of collecting farmers' demand should report reliable figures to be used at higher levels when estimating demand. The officers at higher levels should make their estimation procedures transparent and derive their assumptions from research-based evidence regarding the potential of extension services to increase fertiliser use in the context of Ethiopia. Another policy option is to allow private dealers to distribute fertiliser alongside the cooperatives. This option is likely to result in competitive pressure driving down prices, while optimizing inventories and improving the transmission of price signals. Competing private dealers seeking ways to maximize their profits are likely to optimize stock levels which could reduce retail prices. This point is supported by evidence in neighbouring Kenya and Uganda where following the liberalisation of fertiliser markets, increasing competition and falling prices of fertiliser were observed.

The work presented here could be extended in three main directions. First, similar analyses could be conducted in countries such as Kenya and Uganda, where fertiliser markets have been liberalised. Comparison across countries will provide a basis for more definitive judgments about which setting between strong state control over fertiliser markets, like in Ethiopia, and free markets results in a higher transmission of price signals. Second, in countries where fertiliser procurement is not conducted only once in a year and retail prices fixed accordingly, time series with more observations would make it possible to look at adjustment dynamics and to estimate models that allow for threshold effects, structural breaks and for asymmetry in price transmission. Finally, a study could focus on the stock optimisation and demand estimation problems in Ethiopia. Using linear programming methods, such study could come up with a model to optimize stock levels and reconcile official targets and actual demand for fertiliser.

Acknowledgements

Comments and suggestions by two anonymous reviewers are gratefully acknowledged. Funding for this research was provided by foundation fiat panis and the German Academic Exchange Service (DAAD). Comments and suggestions by Francis Shitawa, Arndt Feuerbacher, Samuel Mburu and Moses Mananyi Kupabado are appreciatively acknowledged. This research was conducted between the Food and Agricultural Policy Group of the University of Hohenheim and the Centre for Rural Development Studies of Addis Ababa University.

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