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Sheep market integration in the Central Rift Valley of Ethiopia

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This study examines the existence of the spatial market integration of the different pairs of sheep markets in the Central Rift Valley of Ethiopia. Using modern time series econometric technique, uncovered compelling pieces of evidence of strong steady state linkages of the various pair-wise combinations of the sampled CRV markets, with only an insignificant few segregated routes. The main conclusion of the study is that despite the geographic segregation of the sheep markets and the presence of fragmented and often inefficient distribution system, price signals and other market information are transmitted efficiently across the markets, thus negating the potential occurrences of unexploited arbitrage opportunities.

Key words: Price integration, spatial transmission, co integration, granger causality, vector autoregression (VAR).

INTRODUCTION

Small ruminants are integral part of livestock keeping in Sub-Saharan Africa (SSA), mainly kept for immediate cash sources, milk, meat, wool, manure, and saving or risk distribution (Kosgey, 2004). They are also sources of foreign currency (Berhanu et al., 2006). Moreover, due to their high fertility, short generation interval, adaptation to rain scanty environment and their ability to produce in limited feed resource they are considered as investment and insurance (Asfaw, 1998). Sheep contribute importantly to the GNP and welfare of individual animal owners. Sheep kept by small holders in Ethiopia are a major source of food consumption and cash income. In addition, to providing income from regular sales, sheep are ready saleable assets and can be traded for grains in time of shocks. Lambs can be sold at about one year of age if reasonably well managed and can provide quicker returns than obtained from the cattle (Wilson, 1986). Measuring spatial price linkages of commodity market in developing countries of Africa has received much attention in the literature because of its implications for food and commercial markets. Competitive market equilibrium under well known conditions in Pareto efficient and this extends to competitive market equilibrium when trade occurs between markets at fixed transport costs (Takayama and Judge, 1971).

Property of competitive spatially equilibrium is characterized by the law of one price (LOP): if trade occurs between two markets, the price in the importing market equals that in the exporting market plus transport costs and the two markets are spatially integrated. However, existence of spatially integrated markets not necessarily implies the Pareto efficiency. Nevertheless,

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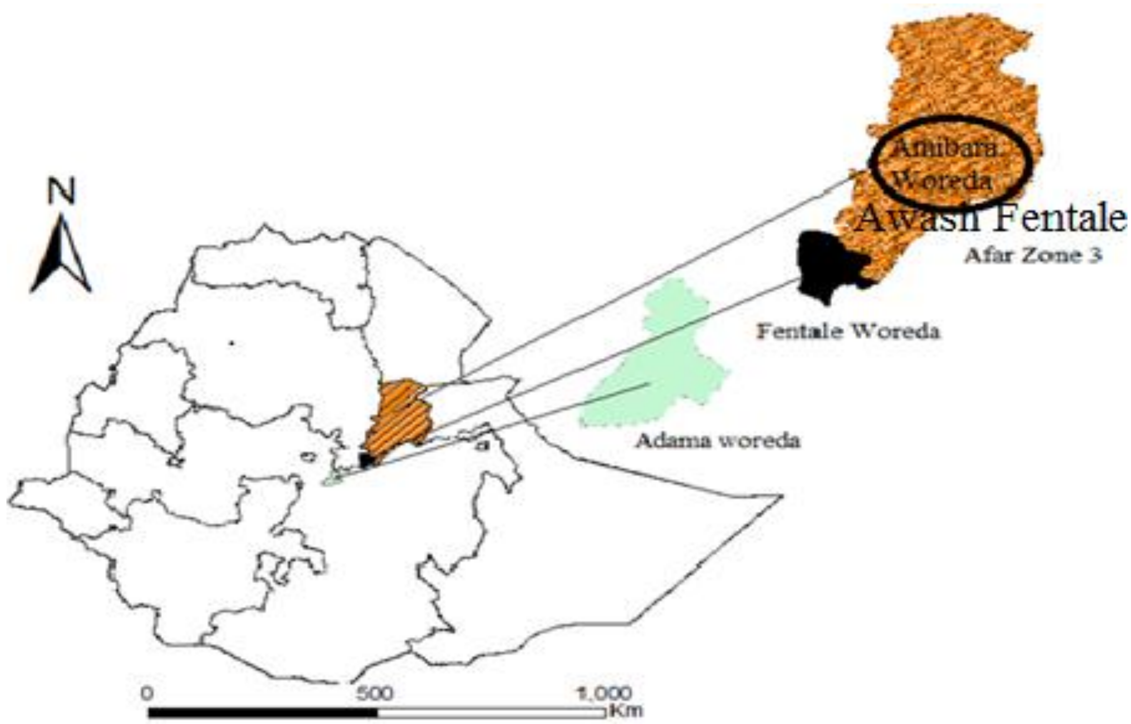

Figure 1. Sample area.

as Ravallion (1987) notes, ‘one can be interested in testing empirically for spatial integration, without wishing to rest the case for or against Pareto optimality outcome. Measurement of integration can be viewed as basic data for an understanding of how specific markets work.’

Objective

This objective is to evaluate sheep spatial market integration in Central Rift Valley of Ethiopia. The specific objectives are to examine the level of integration in the sheep markets in central rift valley of Ethiopia (Figure 1).

METHODOLOGY

Methods of data analysis

Correlation coefficients

Correlation coefficients of real price changes of market pairs are estimated by:

$$r_{ij} = \frac{\Sigma(\Delta P_{i,t} - \Delta\bar{p}_i)\ \Delta P_{j,t} - \Delta\bar{p}_j)}{[\ [\Sigma\ (\Delta\ P_{i,t} - \Delta\bar{p}_i)^2]\ [\ (\Delta P_{j,t}\ - \Delta\bar{p}_j)^{1/2}\ ]\ ]} \quad (1)$$

r_{ij}: the correlation coefficient of market price between the two markets, $(0 \leq r_{ij} \leq 1)$.

Trends of spatial integration

The trends were estimated by the following linear model:

$$SPS_{ij} = \beta_1 + \beta_2 t + \varepsilon \quad (2)$$

Where SPS_{ij} is weekly price of the two spatially separated markets i and j.

Unit root tests

Augmented Dickey Fuller (ADF) test: The general form of this test’s regression looks as follows:

$$\Delta P = \alpha + \beta_t + (\rho\text{-}1)P_{t\text{-}1} + \sum_{i\text{-}1}^{n} \gamma_i \Delta P_{t-I} + \varepsilon \quad (3)$$

Lag identification

The lag identification was done using the Akaike information criteria (AIC):

$$AIC_{ij} = \ln\delta_{ij}^2 + \frac{2q}{N} \quad (4)$$

Where AIC_{ij} is AIC statistic between markets i and j;

Co integration test

The null hypothesis in such procedure is that of no co-integration,

Table 1. Correlation coefficient of ewe grades of body conditions.

Markets	Ewes fat	Ewes moderate	Ewes thin
	Market exchange price		
Werer- Awash	0.64**	0.50*	0.59**
Werer-Addis ketema	0.56**	0.42*	0.69**
Werer-Adama	0.54*	0.53*	0.13
Awash -Addis ketema	0.44*	0.31*	0.76**
Awash-Adam	0.46*	0.52*	0
Addis ketema-Adama	0.46*	0.41*	0

a: Correlation coefficients among different literature are strong (r>0.8), moderate (0.6 ≤ r ≤ 0.8) and weak (r < 0.6). *: Correlation is significant at 0.05 levels. **: Correlation is significant at 0.01 levels. Source: Price data computed (2008-2011).

Table 2. Estimate of trends in spatial price spread of the ewe grades of body condition.

Market pairs	Ewe fat		Ewe moderate		Ewe thin	
	Cons.	Trend coefficient	Cons.	Trend coefficient	Cons.	Trend coefficient
Adam-Addis ketema	1.38*	0.02*	2.39*	-0.01*	0.49	-0.01*
Adama-Awash	1.12*	-0.02*	1.14	-0.01*	0.17	-0.00
Adama-Werer	1.17*	0.00	1.43	0.00	0.62	0.00
Awash-Addis ketema	5.46**	-0.4**	-1.19	0.01*	1.28	0.01*
Awash-Werer	0.45*	-0.2*	0.52	0.00	1.09	0.01
Addis ketema-Werer	0.63**	-0.03**	0.04	0.00	-0.96	0.03**

VEC: Correlations of autocorrelation were conducted for all market pair. **: Significant at 1%; *: significant at 5%. Source: Price data computed (2008-2011).

with the alternative hypothesis of co-integration.

$$P_t = \alpha + \beta X_t + V_t \quad (5)$$

With a co-integrating vector of (1, −β) using ADF:

$$\Delta V_t = \alpha + (\rho-1)V_{t-1} + \sum_{i=1}^{k}\delta \Delta V_{t-i} + \varepsilon \quad (6)$$

Causality tests

The direction of causation in the price information flow was tested by Granger causality test. This test is used to establish the existence of a central market (Granger, 1969).

RESULTS AND DISCUSSION

Correlation coefficients

The ewe and ram was estimated using simple correlation coefficient. Six pair correlations were tested. Spatial sheep (ewe and ram) market pairs where identified by their levels of strength (that is, strong, moderate, and weak), significant at real price exchanges (Table 1). In accordance with this analysis, Werer-Awash and Werer-Addis ketema markets were moderately integrated with 0.64 and 0.56 respectively in grade fat types while the rest indicates weakly integrated including the moderate grade. The least correlation coefficient was recorded at Awash-Adama with moderate grade recording (0.31) followed by the Addis ketema-Adama at (0.41) with the same grade (body condition) which is a weak correlation (r<0.6) but positively correlated.

Trends of spatial integration

The four market pairs were found to be negative trends of SPS in fat grade indicating that these markets where integrating over the past four years (Table 2), while the two markets are closer to arbitrage formation in the sample body condition. Awash-Addis ketema (-0.4) with the trend coefficient was the highest level estimated, followed by Awash-Werer, Addis ketema-Werer and Adama-Awash, respectively. Adama integrated with Addis ketema though it is not showed with degree of improvement which the trend coefficient (-0.02).

Causal test OLS

H_0 = all coefficient of lag of P_{ij} are equal to zero.
H_1 = Coefficient of lag of P_{ij} are different from zero.

Table 3. Granger causality test of ewe grades of fat OLS.

Market pairs	Lag length	Causality (F-value)	P>F	Adj R-squared
Adama-Werer	4	5.94**	0.00	0.68
Adama-Awash	1	2.43*	0.05	0.66
Adam-Addis ketema	1	1.62*[2]	0.12	0.66
Werer-Adama	2	4.30*	0.04	0.93
Awash-Adama	1	4.40*	0.04	0.82
Addisketema-Adama	1	4.78**	0.00	0.63
Awash-Werer	1	2.00*[2]	0.12	0.82
Awsh-Addis ketema	1	2.66*[1]	0.10	0.81
Werer-Awash	1	11.55**	0.00	0.92
Addis ketema-Awash	3	4.69*	0.03	0.63
Addis ketema-Werer	3	3.84**	0.01	0.62
Werer-Addis ketema	3	6.01*	0.02	0.93

**: Causality is significant at 0.01. *: Causality is significant at 0.05. **[1:] Causality is significant at 0.10 (weak). *[2]: Causality is significant at 0.25 (very weak). Source: Price data computed (2008-2011).

Table 4. Augmented Dickey-Fuller unit root test for ewe grades of fat.

Sample markets	Lag length	ADF τ -value	Mackinnon P-value	X^2 at 10 lags ($P > X^2$)	τ -value at D(L)	P-value at D(L)	X^2 at 10 lags ($P > X^2$)
Werer	2	- 4.26***	0.00	14.47 (0.15)	-3.39**	0.05	7.04 (0.72)
Awash	1	-4.56***	0.00	25.26 (0.01)	-4.17***	0.01	24.15 (0.01)
Addis ketema	1	-6.44***	0.00	22.20 (0.01)	-4.38***	0.00	8.66 (0.57)
Adama	4	-6.56***	0.00	28.90 (0.00)	-5.71***	0.00	14.99 (0.13)

Lag length was determined based on the significance level of the lag structure. ***, ** and * indicate significance at 1, 5 and 10% respectively, τ -value in the parenthesis, X^2 = Durbin's alternative test for serial correlation, the values in the parenthesis show the significance level to reject the null hypothesis (Ho: No autocorrelation). Source: Price data computed (2008-2011).

There is reasonable justification that Granger-cause of Werer ewe with grades of fat market on Adama market with significant cause effect to price at lag 4 with (1%) having the adjusted R squared value of 0.68 explaining the effect with the rejection of the null hypothesis, while the vice versa with lag two at the significant level of (5% and above) Adama cause effect on Werer with 4.30 F-value so the causation is a feedback from the two markets at (5%) with strong Granger cause from the former. Addis ketema market to cause influence on the Adama market is very weak (with significant level of 10% and above) (Table 3).

Unit root test

Order of integration of price

$P_t = \alpha + bP_t\text{-}1 + \varepsilon_t$

H_0: the price series for sheep contains unit root,
H_1: the price series for sheep are non unit root.

The hypothesis for the ADF test of unit root can be expressed as:

H_0: $P_t = P_{t-1} + \varepsilon_t$
H_1: $P_t = \Delta P_{t-1} + \varepsilon_t$

The results of the unit root test show that prices are stationary at different differenced orders integration in Werer, Awash, Addis ketema and Adama, which demonstrate that the order of integration in weekly prices is order one, that is I(1) for Awash and Addis ketema, while I (2) and I (4) for Werer and Adama since the analysis of ADF test statistics greater than the critical values of (1%), (5%) and (10%) of the interpolated Dickey-Fuller in absolute term and the Mackinnon P-value approximates to zero; with these the null hypothesis of the unit root rejected in favor of stationarity alternative with the ewe at the grade of fat (Table 4). White noise is a stationary process and there is a useful generalization of the random walk which requires that the first differences are stationary (Table 5):

Table 5. White noise test for ewe with grades of fat.

	Portmanteau test for white noise			
Sample markets	**Portmanteau/Q/statistic at level**	**P>X^2**	**Portmanteau/Q/statistic at lag 4**	**P>X^2**
Werer	4091.44***	0.00	1581.46***	0.00
Awash	1984.98***	0.00	1144.79***	0.00
Addis ketema	712.22***	0.00	378.62***	0.00
Adama	1116.22***	0.00	503.47***	0.00

X^2 = Durbin's alternative test for serial correlation. ***: Significance at 1%. **: Significance at 5%. *: Significance at10%. Source: Price data computed (2008-2011).

Table 6. Engle-Granger co-integration of two step OLS and unit root grade of fat.

Sheep	Markets	Werer	Awash	Addis ketema	Adama
Ewe	Werer		-3.14**	-4.05***	-3.62***
	Awash	-4.26***		-4.23***	-4.53***
	Addis ketema	-6.15***	-5.43***		-6.15***
	Adama	-4.26***	-5.31***	-5.78***	
Ram	Werer		-4.48***	-6.07***	-5.29***
	Awash	-4.95***		-5.32***	-5.33***
	Addis ketema	-7.21***	-6.09***		-6.57***
	Adama	-7.17***	-6.81***	-7.25***	

***, ** and * indicate significance at 1, 5 and 10%, respectively. Source: Price data computed (2008-2011).

$\Delta P_t = \varepsilon_t$, ε_t is stationary.

Co-integration test

Engle-Granger cointegration test (EG): The EG (Engle and Granger, 1987) test uses a more generalized formulation, if β is a vector of coefficients and P_t is a vector of non-stationarity variable, then there will be a cointegration vector β such that:

$$\beta P_t = \varepsilon_t$$

That there will be a linear combination and the left side will be stationary. $\mathcal{E}_t$ will be the deviation from the long run equilibrium of the sheep price variable and is called "equilibrium error". Testing for cointegration is about finding this cointegration vector. By assumption for instance, the price of Werer and Awash markets will have one cointegrating vector. As shown in Table 6, the result of the ADF unit root tests of the residuals at test statistics with comparison to the critical values of 1, 5 and 10%, respectively and considering the Macknnonian p-value to the test statistic after the OLS regression of the EG test involving the different market pairs. The table reveals that out of the 12 possible pairs, all routes produced stationary residuals at 1% significant level for cointegration except that of Werer-Awash the Macknnonian P-value shows 0.03 significance for the test statistic of 3.14, the critical value of 5% with grade of fat.

Maximum Eigen value tests: The first of the vector autoregression (VAR) based EG-ADF tests for econometric cointegration is put into application, and the outcomes are shown in Table 6. The table shows computed values of the Johansen Maximum Eigen value test statistic for the various market pairs. The higher the value for trace statistic, it is more likely market pairs linked in a steady state way. The critical values for the test use 5% (Table 7).

Johansen trace statistics test: Using an alpha option in the analysis, there is a possibility to get short term adjustments price parameters in the out. This helps to investigate which market responds more if there is a market shock in the routes of paired markets or the market price response to change of exogenous factors in the marketing system of sheep in the Central Rift Valley of Ethiopia. From these differenced market pairs in Table 8, signifies response to shock the higher the P> chi^2 the lesser the degree of responds to shock in the market system. With this justification in the pairs of market Werer-Awash, the Awash market responds faster more to market price shocks with differenced value of 0.00 which is more significant compared to Werer market. Considering the route of Awash-Adama price movement

Table 7. Maximum Eigen value statistics of Johansen cointegration for ewe grade of fat.

Market pair	Johansen maximum Eigen value test statistic			
	Maximum rank	Eigen value	Trace statistic	Critical value at 5%
Werer-Awash	1	0.10	15.64	3.74
Werer-Addis ketema	1	0.18	18.64	3.74
Werer-Adama	1	0.21	16.06	3.74
Awash-Addis ketema	1	0.18	19.87	3.74
Awash-Adama	1	0.18	20.23	3.74
Addis ketema-Adama	1	0.19	37.55	3.74

Zero rank values indicate lack of cointegration with p > 0.05. Source: Price data computed (2008-2011).

Table 8. Market pairs respond to market shock for sheep.

Markets pairs	Ewe grade of fat		Markets pairs	Ram grade of fat	
	Adjustment parameters			Adjustment parameters	
	Ch^2	$P> Ch^2$		Ch^2	$P> Ch^2$
Werer	0.29	0.59	Werer	4.27	0.04
Awash	13.14	0.00	Awash	8.41	0.00
Werer	4.51	0.03	Werer	4.10	0.04
Addis ketema	39.83	0.00	Addis ketema	35.13	0.00
Werer	3.10	0.08	Werer	4.27	0.04
Adama	21.33	0.00	Adama	8.41	0.00
Awash	2.07	0.15	Awash	1.21	0.27
Addis ketema	28.35	0.00	Addis ketema	22.37	0.00
Awash	9.63	0.00	Awash	9.68	0.00
Adama	13.51	0.00	Adama	30.50	0.00
Addis ketema	45.67	0.00	Addis ketema	8.77	0.00
Adama	2.03	0.15	Adama	18.76	0.15

Chi^2 = Result of trace statistic. Source: Price data computed (2008-2011).

respond to shock both markets responds at faster rate which having 0.00 significant level.

Inference drawn from the co- integration test result: A result reached by the empirical evaluation of econometric co-integration with the three tests used are almost unanimous in their results of the Central Rift Valley market for sheep were highly integrated notwithstanding the presence of a few market pairs that are weak spatially integrated when the price trend is analyzed using Maximum Eigen value statistics. These markets pair which curiously involve Werer-Awash and vice versa way exhibit aberrant behavior, the explanation of which is beyond the scope of this study. Just the same, out of the 12 possible regional market pairs, 11 are found to be spatially integrated, for a better than 98% successes rate in considering the ewe and ram.

Granger causality of market prices VAR model: The information provided by Table 9 indicates the high level of integration among ewe with grade of fat markets. Except for some non-linked markets, the various market pairs exhibit Granger causality in either directions, or are linked in a feedback relationship. Only about 3 market pairs show evidence of segregation, 9 of which coincide with the ones identified by the Engle-Granger and the Johansen cointegration test approaches. The only non-linked pairs identified by the Granger causality approach not identified by the other tests is the Werer-Adama and Awash-Addis ketema route which showed a value of 0.18 and 0.24, respectively. The symbols exhibited in Table 10 are the causality directions of the market. For instance, a symbol => means that the information provided by the row market contribute in the price formation in the column market. A symbol <= on the other hand, suggests that the column market is the one providing the information for the formation of prices in the row market. When the symbol <=> is noted for the market pair, the conjecture is that there is some sort of feedback statistical causality between the paired market. Finally, the empty space

Table 9. Granger causality wald test for sheep using VAR model.

Market pairs	Ewes grade of fat		Market pairs	Ram grade of fat	
	Ch^2	$P> Ch^2$		Ch^2	$P> Ch^2$
Werer-Awash	0.41	0.82	Werer-Awash	4.72**	0.03
Awash-Werer	4.27*	0.10	Awash-Werer	4.02**	0.05
Werer-Addis ketema	5.99**	0.05	Werer-Addis ketema	6.15***	0.01
Addis ketema-Werer	16.57***	0.00	Addis ketema-Werer	20.87***	0.00
Werer-Adama	3.39	0.18	Werer-Adama	7.25***	0.01
Adama-Werer	17.83***	0.00	Adama-Werer	16.59***	0.00
Awash-Addis ketema	2.87	0.24	Awash-Addis ketema	2.47	0.12
Addis ketema-Awash	5.29*	0.07	Addis ketema-Awash	9.48***	0.00
Awash-Adama	3.98*	0.10	Awash-Adama	8.40***	0.00
Adama-Awash	6.33**	0.04	Adama-Awash	12.03***	0.00
Addis ketema-Adama	19.77***	0.00	Addis ketema-Adama	2.51	0.11
Adama-Addis ketema	1.61*	0.10	Adama-Addis ketema	10.04***	0.00

Chi^2 = Result of causality EG. ***: Significance at 1%. **: Significance at 5%. *: Significance at 10%. Source: Price data computed (2008-2011).

Table 10. Causality directions of linked markets based on results of Granger causality test.

Markets	Werer	Awash	Addis ketema	Adama
Werer		<=	<=>	<=
Awash			<=	<=>
Addis ketema				<=>

=> means the row Granger cause the column price formation, <= means the column Granger cause the row price formation, <=> price Granger cause feedback each other. Source: Price data computed (2008-2011).

implies market pair to be non-integrated or non causation to each other.

CONCLUSION AND RECOMMENDATION

The primary result of the study is the empirically determined high level of spatial market integration of the inter-market sheep prices. Out of the twelve possible sample market pairs, using Granger-Causality Wald test using VAR model for cointegration showed statistically significant level of spatial integration except Werer-Awsh, Werer-Adama and Awash Addis ketema for ewes with grades of fat yet it is verified with other test the significant integration spatial market prices with results of the three empirical procedures confirming each other's results. Only the market pairs of Awash-Addis ketema and vice versa routs are found to be non-spatially integrated using maximum Eigen value statistics of Johansen cointegration test for ewe grade of fat. This does not mean that no trading is possible along these routes and there exists market failures along these routes. In the integrated pairs, what the study uncovered the statistical alignment of prices in these pairs. In other words, there exist long-run equilibrium relationship of the prices in the identified market pairs, and that the price transmission mechanism is stationary with having no unit root test for the sample year taken. The Granger causality OLS tests conducted on all sampled market pairs identified what the theory predicts that at least a unidirectional causality exists in the integrated market pairs. Interestingly, market information in deficit sample is apparently being used in the price formation at the sheep producing (the rural markets).

In some deficit-surplus market pairs, significant feedback causality is noted. All of the inference procedures used in the study generated almost identical results except few slight exceptions, thus giving me sufficient confidence on the empirical validity of my results, the interregional sheep price transmission system is highly efficient. Spatial market integration should foster a sustainable use expected to favor the sharing of risk across markets smoothing idiosyncratic price variations. Using weekly sheep price data from Central Rift Valley, results show that markets are integrated. Prices are co-integrated, short-term integration is largely prevailed and there is evidence of market integration. Yet large price differentials occasionally persist between adjacent areas for periods of time. In the long run, substantial investment in transportation system is required to improve the integration of markets. Market integration will play a crucial role in improving the food security situation of the region, which account for the highest number of meat deficit district in the country. In the case of the interregional market for sheep in the CRV of Ethiopia, the study uncovered the existence of a high level of spatial integration. Higher than 95% of all market pairs have long-run equilibrium price linkages, and that short-run deviations from equilibrium will readily be corrected through the efficient transmission of price setting information.

The following are the possible implications of the findings made:

(i) The results shown in the discussion part dictate that the ‘law of one price’ was found in operation in the inter-market sheep price of the CRV for different body condition category for ewe and ram,
(ii) For the sheep traders to take advantage of the high level of spatial market integration, the problem of the highly inefficient and fragmented distribution and transportation systems must be addressed with market information backup systems,
(iii) Because of the high level of spatial integration of markets, government price support and other market-oriented policies are expected to achieve their intended goals in Werer, Awash and Addis ketema with food security programs furthermore.

The greater the extents of domestic market integration, the more modest are the informational and technical demands necessary for policy formulation at Woreda, and regional level if aggregated from different direction, it can be used for higher level policy formulation.

(i) Further research on market integration for sheep using advanced level II (with transfer costs data) and level III (with transfer costs and trade flows data) analysis should be supported,
(ii) Market integration studies across marketing stages must also be encouraged,
(iii) Efforts should also be expended to empirically determine the extent of spatial market integration for other major agricultural commodities and its by products.

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