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Spatial and Vertical Market Integration and Price Transmission in the Ethiopian Banana Supply Chain

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Abstract: Better market integration leads to faster transmission of price signals that increase producers' and consumers' welfare. Efficient market integration encourages producers to specialise according to their comparative advantage and use superior technologies that have a great impact on banana productivity. Therefore, this study investigated the degree of market integration and spatial and vertical price transmission and identified the direction of price formation in the banana supply chain. Results of the autoregressive distributed lag (ARDL) bounds test for co-integration indicated that wholesale prices had a significant effect on both banana producers' and retailers' prices in both the long run and short run. The central markets determine the long- and short-run producers' prices in the supply chain. The results of the error-correction version of the ARDL model showed a considerable degree of vertical price transmission from the central wholesale market to the local producer markets, indicating market integration. The findings imply that local banana market prices in surplus areas are asymmetrically integrated and transmitted with central banana market prices/deficit areas in Ethiopia because of the geographic distance between markets, market power, and high transportation costs. Market power and concentration at various stages of supply chains can cause asymmetric price transmission. The government should take actions to address banana market failures to increase banana productivity as well as decrease distribution costs, thus leading to higher producers' and consumers' welfare by increasing profits and decreasing food costs, respectively.

Keywords: Leadership position in banana supply chain, Wholesale markets, Vertical and spatial market integration, Transmission, Price formation

JEL Classification Codes: D82, E31, L11, and Q13

1. Introduction

In Ethiopia, banana production is a means of livelihood for all producers (CSA, 2017). Banana production is also a source of income and food for rural and urban people. It provides jobs and income and helps secure food for urban dwellers at different levels of supply chains. Banana production covers approximately 60% of the total fruit area, approximately 68% of the total fruits produced, and approximately 38% of the total fruit-producing farmers in Ethiopia (CSA, 2017). A map of the deficit and surplus banana markets is presented in Appendix Figure 1 and describes shock transmission along the banana supply chain in Ethiopia. Producers sell their bananas mainly to wholesalers and retailers in local markets and farm gates (Tarekegn *et al*., 2020).

Banana supply chains suffer from weak linkages within the banana market and inadequate integration of actors throughout the supply chain in Ethiopia. Banana markets in surplus areas suffer from weak market coordination. The surplus and deficit markets are linked by asymmetric information. Banana supply chains are distinguished by numerous links that add little value and result in only a small portion of the retail price reaching farmers due to the highly perishable nature of bananas and a lack of local capacity to process or store the commodity. Banana supply chains are inefficient and disjointed, and marketing efficiency in Ethiopia is dismal. Poor networks along supply chains are key indicators of market failures that discourage producers from using superior technologies (Habte *et al*., 2016; Habte *et al*., 2020; Shikur *et al*., 2020; Shikur, 2021). As a result, farmers enjoy the lowest share of the selling price of bananas among actors in banana supply chains because of imperfect markets and poor market linkages (Getahun *et al*., 2017; Tarekegn *et al*., 2020).

Therefore, it is critical to explore the impacts of trader prices on banana producers' prices for a variety of reasons. The effect of traders' prices on producers' prices is yet unknown from the banana supply chain perspective, although spatial and vertical supply chain connections are major drivers of market integration, price adjustment, and price formation. The asymmetric responses shed new light on producer–wholesale– retail banana market performance. This study differs from other studies in terms of analysis method, inclusiveness, and the context of the study. The study of price formation, price adjustment, and market integration between producers and traders is important to develop and implement appropriate policies in the supply chain that could reduce market failures due to interlinked challenges such as market power and asymmetric information that have positive implications for producers' and consumers' welfare. Analysis of how geographic prices adjust to shocks and the extent of efficiency of geographic markets can provide useful information that can assist in addressing low banana market integration and price adjustment.

The hypotheses for this study were tested and derived based on existing banana market structures. This study hypothesised that long-run price movements in local markets were influenced by the central wholesale market. Banana producers' prices in Arba Minch and Tepi were expected to be influenced by retail prices in Addis Ababa, Arba Minch, and Tepi. The hypothesis states that changes in Addis Ababa prices have no effect on price changes in the two local markets. The Granger causality test was used to test the hypothesis that changes in trader prices caused changes in the two local markets, but not vice versa. The ARDL bounds test for co-integration was used in this study to model the spatial and vertical equilibrium relationship between the producer and trader prices of bananas in Ethiopia.

This study investigated the direction of price formation between pair banana markets using time series data observed from 2008 to 2020 at a monthly frequency. Therefore, the paper contributes to the existing literature. The remainder of this study is organised as follows. This study reviews market integration and price transmission in Section 2. The study describes the data and methods of analysis in Section 3. Section 4 presents the findings and discussions. Finally, the policy implications are presented in the concluding section.

2. Market Integration and Price Transmission

Market integration is explained as the extent of price transmission between two, either vertically or spatially, related markets. Spatial integration implies a perfect price transmission where a price change in one market causes an identical adjustment in another market. In spatial integration, inter-linkages exist between surplus and deficit commodity markets, whereas vertical integration includes different stages in marketing and processing channels. Vertical market integration analysis can explain farmers' and marketing institutions' bargaining power (Barrett & Li, 2003).

Price transmission is a change in one price that causes a change in another price (Balke & Fomby, 1997). Generally, it is measured in terms of transmission elasticity, which is explained as the percentage change in the price in one market given a 1% change in the price in another market. Price changes are transmitted along spatial and vertical food supply chains (LIoyd, 2016). Price transmissions are divided into three categories: vertical, spatial, and cross-commodity transmissions. Vertical price transmission exists when there are interactions between prices at different stages. It is described by the degree (of completeness of pass-through price change), speed, and type of price adjustments through the supply chain. Such changes are usually represented as responses to shocks at certain points in the chain. Horizontal price transmission refers to the existing linkage among different markets at the same position in the supply chain. The notion of horizontal price transmission usually refers to price linkages across markets (i.e. spatial price transmission).

Market power and concentration at various stages of supply chains can cause asymmetric price transmission (Meyer & von Cramon-Taubadel, 2002). Product perishability (Ward, 1982), high transaction costs (Balke & Fomby, 1997; Balcombe, 2007) and public intervention in producer prices

(Habte, 2016), cause asymmetric price transmission. High transaction costs are also responsible for asymmetry in price transmission between markets (Balke & Fomby, 1997; Balcombe, 2007). Meyer and von Cramon-Taubadel (2002) observed that a possible implication of asymmetric price transmission was that consumers were not benefiting from price reductions at the producer level, or producers might not benefit from price increases at the retail level. Asymmetric price transmission has been studied using different econometric methods, from classical specification to co-integration and threshold models (Balke & Fomby, 1997). Kuiper *et al*. (2003) pointed out that high transaction costs impeded market integration, and as a consequence, not all spot markets performed equally well.

Generally, earlier studies concentrated on inter-regional spatial grain and fruit market integration in Ethiopia (Getnet *et al*., 2005; Jaleta & Gebermedhin, 2012; Habte, 2014; Wondimu, 2015; Habte; 2016; Haile *et al*., 2017; Yami, *et al*., 2017), and analytical research on vertical banana price transmission is largely limited in Ethiopia. Empirical case study evidence reveals a mixed pattern of interrelationships between air transport trader and producer prices, implying either unidirectional or bidirectional causality. Therefore, this paper attempts to empirically investigate market integration and the extent of price transmission in the banana supply chains in Ethiopia. Specifically, only a few studies have investigated the relationship between the directions of banana price formation in developing countries (Adeoye *et al*., 2011; Fatin *et al*., 2020). The various factors in the case studies could also be attributed to the diverse findings in these studies concerning the causal direction of the two variables. Adeoye *et al*. (2011) applied Granger causality to Nigerian time series data, whereas Fatin *et al*. (2020) applied Granger causality to Indonesian time series data. Adeoye *et al*. (2011) indicated a causal movement from rural to urban prices at the 10% level. If the wholesale market quickly absorbs market signals from both the consumption and production points, the wholesale price may outperform both retail prices. They discovered no significant causal relationship between the two Nigerian markets at the 10% significance level. In Indonesia, banana prices were formed unidirectionally, from producer to consumer. To the best of my knowledge, this is the first attempt in Ethiopia to investigate the degree of vertical and spatial price transmission in the banana supply chain; this study aims to bridge the existing gap.

3. Methodology

3.1. Description of the Study Areas and Data Collection

Southern Nations Nationalities and People Regional State (SNNPRS) of the country and Addis Ababa were purposively selected because the major banana-producing zones and the largest share of the urban population and demand for banana were found in SNNPRS and Addis Ababa in Ethiopia, respectively. The local and central markets in Ethiopia are chosen with care, considering the country's largest banana production and banana demand. The selection of local markets in this study is motivated by the fact that these are the major banana producing areas in Ethiopia. Arba Minch and Tepi banana surplus areas are also the largest banana producers in the country. Addis Ababa is assumed to be the central market, with Arba Minch and Tepi serving as local markets. Addis Ababa is the capital city of Ethiopia. SNNPRS is among the ten National Regional States (NRS) of the country. Ethiopia has limited banana surplus markets and many banana deficit markets. The surplus areas were found in the Bench-Maji and Gamo Gofa zones in Ethiopia. Arba Minch and Tepi are located in major banana-producing zones. Tepi is located in the Bench-Maji zone, which ranks second in banana production in Ethiopia, next to Arba Minch, which is situated in the Gamo Gofa Zone. Arba Minch is geographically closer to Addis Ababa than to Tepi. Arba Minch and Tepi are located at a distance of approximately 500 km south of Addis Ababa and 561 km southwest of Addis Ababa, the capital city of Ethiopia, respectively.

Data on banana prices across spatially and vertically separated markets were compiled to measure the degree of integration between these markets. The prices of producers, wholesalers, and retailers in three banana markets were compiled for this study based on the availability of data in surplus and deficit markets. Data on the monthly average banana producer, retail, and wholesale prices were compiled for 12 years (2008:1 to 2020:12). Average monthly producer, wholesaler, and retailer prices for banana were collected from Ethiopian Central Statistical Agency (CSA) databases. Data were analysed using STATA software.

3.2. Data Analysis

The autoregressive distributed lag (ARDL) model was employed for this study to study the spatial and vertical price behaviours of bananas, identify determining factors to avoid uncertainty about causality, and find evidence that central wholesale prices are determining factors for local prices. Market integration and price transmission were examined by employing the time series techniques of the ARDL Bounds co-integration test. The study used the ARDL approach developed by Pesaran and Shin (1999) and Pesaran *et al.* (2001), which has advantages over conventional co-integration analyses. For instance, the ARDL approach to co-integration has some advantages over other co-integration approaches, such as those of Engle and Granger (1987), Johansen (1988), and Johansen-Juselius (1990). The

ARDL approach to co-integration is not only capable of differentiating between dependent and independent variables but can also simultaneously investigate both long-run and short-run dynamic relationships. It also overcomes the endogeneity problem and provides unbiased estimates of the long-run model (Harris & Sollis, 2003).

Before identifying the relationship between variables, the non-stationarity of selected data series at the level and the first difference were checked using the Augmented Dickey– Fuller (ADF) unit root test. An ADF test was run to check the existence of an integrated order of two (I (2))and excluded the probability of dealing with I (2) variables. The results in Appendix Table 1 indicate that there were no variables with I (2*).* In particular, the variables appear to be I (0) and I (1). The ARDL model for co-integration testing in this study is specified as follows:

$$\Delta A_t = \alpha_{01} + \gamma_{12} A_{t-1} + \gamma_{21} aw_{t-1} + \gamma_{31} ar_{t-1} + \sum_{i=1}^{p} \beta_{1i} \Delta A_{t-i} + \sum_{i=0}^{q} \beta_{2i} \Delta aw_{t-i} + \sum_{i=0}^{r} \beta_{3i} \Delta ar_{t-i} + \varepsilon_{1t} \quad (1)$$

$$\Delta T_t = \alpha_{02} + \gamma_{12} T_{t-1} + \gamma_{22} aw_{t-1} + \gamma_{32} ar_{t-1} + \sum_{i=1}^{p} \beta_{1i} \Delta T_{t-i} + \sum_{i=0}^{q} \beta_{2i} \Delta aw_{t-i} + \sum_{i=0}^{r} \beta_{3i} \Delta ar_{t-i} + \varepsilon_{2t} \quad (2)$$

$$\Delta aw_t = \alpha_{03} + \gamma_{13} A_{t-1} + \gamma_{23} aw_{t-1} + \gamma_{34} ar_{t-1} + \sum_{i=1}^{p} \beta_{1i} \Delta A_{t-i} + \sum_{i=0}^{q} \beta_{2i} \Delta aw_{t-i} + \sum_{i=0}^{r} \beta_{3i} \Delta ar_{t-i} + \varepsilon_{3t} \quad (3)$$

$$\Delta ar_t = \alpha_{04} + \gamma_{14} A_{t-1} + \gamma_{24} aw_{t-1} + \gamma_{34} ar_{t-1} + \sum_{i=1}^{p} \beta_{1i} \Delta A_{t-i} + \sum_{i=0}^{q} \beta_{2i} \Delta aw_{t-i} + \sum_{i=0}^{r} \beta_{3i} \Delta ar_{t-i} + \varepsilon_{4t} \quad (4)$$

$$\Delta aw_t = \alpha_{05} + \gamma_{15} T_{t-1} + \gamma_{25} aw_{t-1} + \gamma_{35} ar_{t-1} + \sum_{i=1}^{p} \beta_{1i} \Delta T_{t-i} + \sum_{i=0}^{q} \beta_{2i} \Delta aw_{t-i} + \sum_{i=0}^{r} \beta_{3i} \Delta ar_{t-i} + \varepsilon_{3t} \quad (5)$$

$$\Delta ar_t = \alpha_{06} + \gamma_{16} T_{t-1} + \gamma_{26} aw_{t-1} + \gamma_{36} ar_{t-1} + \sum_{i=1}^{p} \beta_{1i} \Delta T_{t-i} + \sum_{i=0}^{q} \beta_{2i} \Delta aw_{t-i} + \sum_{i=0}^{r} \beta_{3i} \Delta ar_{t-i} + \varepsilon_{4t} \quad (6)$$

where A_t and T_t are the prices of Arba Minch and Tepi banana producers in the period t, respectively, aw_t is the wholesale market price in the period t, ar_t is the price of banana retailers in the period t, which are allowed to be purely I (0) or I (1) or co-integrated, γ and β are coefficients; α is constant; p, q, and r are optimal lag orders; the lengths for p, q, and r are not the same; ε_t captures the disturbance term.

Under the null hypothesis of no co-integration, the bounds test is primarily based on the joint F-statistic, which has a non-standard asymptotic distribution. The first step in the ARDL bound test is to estimate the three equations (1, 2, 3) by employing ordinary least squares (OLS). The next step of the ARDL bounds test procedure is to test for a long-run relationship among the variables by conducting the F-statistic test for the joint significance of the coefficients of the lagged levels of the variables, H0: $\beta_1 = \beta_2 = \beta_3 = 0$ suggesting the absence of a long-run relationship and an alternative hypothesis (the presence of co-integration) of H_1: $\beta_1 = \beta_2 = \beta_3 = 0$. The calculated F-statistics are compared with tabulated F-statistics (95% bounds and 99% bounds) values estimated by Pesaran *et al*. (2001), which are split into lower critical bounds (I (0)) and upper critical value bounds (I (1)). The ARDL bounds test for co-integration is used to estimate the long-run relationships and short-run dynamic relationships among the variables of interest. The present study used the ARDL to evaluate the existence of a long-term relationship among prices. The ARDL long-run model for the surplus banana market and deficit banana market was expressed as:

$$A_t = \alpha_{01} + + \sum_{i=1}^{p} \beta_{1i} A_{t-i} + \sum_{i=0}^{q} \beta_{2i} aw_{t-i} + \sum_{i=0}^{r} \beta_{3i} ar_{t-i} + + \varepsilon_t \quad (7)$$

$$T_t = \alpha_{01} + + \sum_{i=1}^{p} \beta_{1i} T_{t-i} + \sum_{i=0}^{q} \beta_{2i} aw_{t-i} + \sum_{i=0}^{r} \beta_{3i} ar_{t-i} + + \varepsilon_t \quad (8)$$

where all variables are as earlier defined, β_1, β_2, and β_3 are ARDL long-run coefficients, and ε_t is the white noise error term.

Following Pesaran and Shin (1999), the error-correction version of the ARDL model was adopted to study price adjustment. The error correction model considers the adjustment of short-run and long-run disequilibrium in markets and the time to remove disequilibrium in each period. In terms of efficiency, prices are transmitted fully and completely under efficient market conditions. The coefficient of price adjustment with a negative sign indicates a movement back towards equilibrium; a positive sign reflects a movement away from equilibrium. The error-correction version of the ARDL model is specified in equations 9 and 10.

$$\Delta A_t = \alpha_{0j} + \theta ECT_{t-i} + \sum_{i=1}^{p} \gamma_{1i} \Delta A_{t-i} + \sum_{i=0}^{q} \gamma_{2i} \Delta aw_{t-i} + \sum_{i=0}^{r} \gamma_{31} \Delta ar_{t-i} + \varepsilon_t \quad (9)$$

$$\Delta T_t = \alpha_{0j} + \theta ECT_{t-i} + \sum_{i=1}^{p} \gamma_{1i} \Delta T_{t-i} + \sum_{i=0}^{q} \gamma_{2i} \Delta aw_{t-i} + \sum_{i=0}^{r} \gamma_{31} \Delta ar_{t-i} + \varepsilon_t \quad (10)$$

where all variables are as earlier defined, θ is the speed of adjustment, ECT_t is the coefficient of the error correction term, which is obtained as a residual from the long-run relationship in equation 2; γ_1, γ_2, and γ_3 are the short-run dynamic coefficients of the model's convergence to equilibrium, and ε_t is the white noise error term. The sign Δ denotes the difference operator.

Granger causality analysis is a useful tool for examining causal interactions between two time-series data. The presence of long-run and short-term relationships between two variables implies the presence of causality in at least one direction (Granger, 1988). A substantial correlation between pair prices does not imply causal relationship. Thus, the co-integration test and error correction model are not sufficient to determine the direction of causality between the two time series data. Thus, the Granger causality test was used to determine the direction of the interconnection. The Granger causality test consisted of two variables, wholesale and producer prices, expressed as follows:

$$PB_t = \alpha_1 + \sum_{j=1}^{k} \beta_j \Delta PB_{t-j} + \sum_{i=1}^{k} \beta_i PW_{t-i} + u_{1t} \tag{11}$$

$$PW_t = \alpha_2 + \sum_{i=1}^{k} \beta_i PW_{t-i} + \sum_{j=1}^{k} \beta_j \Delta PB_{t-j} + u_{2t} \tag{12}$$

where, PB_t and PW_t are banana producer prices and banana wholesaler prices, respectively.

4. Empirical Results

4.1. Results of the Stationarity Test

Time series data analysis in ARDL modelling frameworks typically begins by checking for individual variable stationarity and combined linearity (co-integration) of all variables. The results of the ADF test, which was used to determine the order of integration, are shown in Appendix Table 1. The results in Appendix Table 1 show that the null hypothesis of no unit roots for the time series was rejected for banana prices, except for Arba Minch prices at this level. On the other hand, all variables were found to be stationary at the first difference with and without the constant, which means that unit roots in the first difference were rejected at the 1% level of significance.

4.2. Results of the ARDL Bounds Tests for Co-Integration

The results of the bound co-integration test provided strong evidence for the existence of long-run co-integration among markets (see Appendix Table 2). From these results, it was clear that there was a long-run relationship among the variables at the 1% and 5% levels when APP, AAPW, TPP, and TRP were dependent variables. F-statistics for these variables were greater than the lower-bound and upper-bound critical values (Appendix Table 2). As a result, the null hypotheses of no co-integrations among time-series data in equations 1-5 were not accepted.

4.3. Long and Short-Run Relationships in Ethiopian Banana Supply Chains

The coefficients of the error correction term show the speed of convergence to the long-run equilibrium due to the price shock. The coefficients of the ECT (Table 1) have the right sign for each regressor variable, and the equilibrium error correction coefficient was statistically significant, implying that there was an adjustment in the retail price of banana back to the long-run (equilibrium) position once there was disturbance due to shocks. The coefficients of the adjustment vector for retailer markets had a negative sign and were significant at the 1% level, indicating that short-run price movements along the long-run equilibrium path were stable. The Arba Minch and Addis Ababa retail prices had a positive and significant effect on Tepi retail prices in the short and long run, respectively. The estimate of the error correction coefficients for the banana retail markets indicated that the banana market was significant at the 1% level with a right sign signifying disequilibrium eventually. Retailer prices could be corrected by approximately 60% in the Arba Minch retail market and 35% in the Tepi retail market in the short run; thus, the short-run price movements along the long-run equilibrium path were stable (Table 1).

Table 1: Results of ARDL and Error Correction Models

Variable	*Arba Minch*	*Tepi*
	Coefficient	*Coefficient*
Arba Minch/Tepi retail price (LR)	0.93**(0.43)	-0.16 (0.22)
Addis Ababa retail price (LR)	-0.25 (0.18)	0.38***(0.08)
Arba Minch/Tepi retail price (SR) (D1)	-0.13 (0.30)	0.15**(0.06)
Addis Ababa retail price (SR)(D1)	-0.01 (0.26)	0.09 (0.12)
Adjustment (ECT)	-0.60***(0.12)	-0.35***(0.11)
Constant	2.52***(0.83)	-0.01 (0.42)
Diagnostics Test	Normality Test (χ^2_n), JB=5.79 (0.05)	
Hetroskedasticity test (χ^2_{ht}) = 0.98(0.32)	Kurtosis= 6.79	
Serial correlation test (χ^2_{sct}) = 7.43(0.41)		

Notes: Values of standard errors are in parentheses. ***, **, *, denotes significance at the 1%, 5%, and 10% levels, respectively. Furthermore, the diagnostic tests are significant at 5%, except that it was not rejected at 5%, as the Kurtosis value is above, indicating that the residual error is normal. The dependent variable is Arba Minch and Tepi producer prices of bananas, and the independent variables are Arba Minch and Tepi retailer prices and Addis Ababa banana wholesaler and retailer prices.

Source: Author's calculations based on Ethiopian CSA databases (2022).

The study carried out diagnostic tests, such as normality heteroskedasticity and autocorrelation tests, to obtain the validated model results. The results indicated that the error term in the distributed lag model was not serially correlated (see Table 1, 2 & 3). The models were free from the heteroskedasticity problem that may lead to misleading inference.

The results of the speed of price adjustment vectors in banana supply chains are displayed in Table 2. The Addis Ababa banana wholesale price had a positive and significant impact on surplus banana markets during both the short and long run at the 5% level (Table 2). The magnitude of the coefficient indicates the speed of adjustment back to the equilibrium position once the system was in disequilibrium. Arba Minch prices are adjusted to eliminate approximately 60% of a unit negative change in the deviation from the equilibrium relationship caused by changes in Addis Ababa prices. Similarly, Tepi prices adjust to eliminate approximately 35% of a unit negative deviation from the long-run. Overall, there appears to be a significant difference in the elimination of negative discrepancies. These findings indicate that Ethiopian banana markets are not well integrated. This is especially true between Addis Abeba's deficit markets and the Southern region's surplus markets. While prices in local markets may be driven primarily by central market prices plus marketing costs in the post-harvest period, increases in local market prices during the pre-harvest period may draw supplies from central markets, raising prices there.

Following agricultural market liberalisation, Ethiopia's emerging agricultural market structure is characterised by power concentration (Shikur, 2020; Zewdie, 2022). Information asymmetry characterises the relationship between wholesalers and producers, giving the former relative bargaining power. This is bolstered by the fact that there are relatively few wholesalers in banana supply chains compared with the large number of banana producers selling small quantities of produce. Wholesalers have both horizontal and vertical linkages along the supply chain, whereas producers only have vertical linkages. As a result, through targeted interventions at the central level, the government's institutional role in improving producers' marketing margins and the overall performance of banana markets can be influenced.

The dynamic speed of adjustment for the Tepi banana producer price was relatively slower (-0.33) in absolute value than the Arba Minch banana producer price, and it was a reflection of asymmetric price transmission with respect to speed. The agricultural markets have become increasingly integrated over the last two decades, following the long-term trend of transportation advancements, transaction costs, and barrier reduction (Habte, 2016). Transportation advancements benefit society by lowering transportation costs for actors and allowing more people and businesses to interact with one another. Reduced transportation costs may improve market efficiency (Shikur, 2022).

Table 2: Results of ARDL and Error Correction Model for Vertical Price Transmission

Variable	*Arba Minch*	*Tepi*
	Coefficient	*Coefficient*
Arba Minch/Tepi retail price (LR)	-0.05 (0.09)	0.36 (0.37)
Addis Ababa retail price (LR)	0.10 (0.14)	0.03(0.15)
Addis Ababa wholesale price (LR)	0.62*** (0.08)	0.10** (0.04)
Arba Minch/Tepi retail price (SR) (D1)	0.03 (0.06)	-0.29 (0.13)
Addis Ababa retail price (SR)(D1)	-0.10 (0.11)	0.13 (0.23)
Addis Ababa wholesale price (SR)(D1)	0.43** (0.21)	0.29** (0.11)
Adjustment (ECT)	-0.71*** (0.18)	-0.33*** (0.10)
Diagnostics Test	Normality Test (χ^2_{n})	
Hetroskedasticity test (χ^2_{ht}) = 0.56 (0.21)	JB=7.11(0.03)	
Serial correlation test (χ^2_{sct}) = 8.11(0.19)	Kurtosis 8.07	

Notes: The lag length was selected on the basis of the Akiake Information Criteria and F-test considering a maximum lag of four. The Ardllag lengths for Arba Minch/Tepi retail price, Addis Ababa retail price, and Addis Ababa wholesale price, respectively, are lags (1, 1, 1, 1). The values of the standard errors are in parentheses. Negative coefficients are error correction terms (ECT) showing adjustment to decreasing deviations from long-run disequilibrium.

Source: Author's estimations from the Ethiopian CSA database (2022).

The coefficients of the adjustment vector for Arba Minch and Tepi producer prices had a negative sign and were significant at the 1% level, indicating that the short-run price movements along the long-run equilibrium path were stable. The magnitude of the equilibrium error correction coefficient (–0.71) indicated that 71% of the previous month's deviation from the equilibrium position was corrected in a particular month. The dynamic speeds of adjustment for speed of price transmission were slower for Tepi producer price, which may be due to transportation costs, imprecise price information, longer geographic distance from the central market, and logistics infrastructure. One possible explanation for the slower price transmission in the Tepi local market might be the relatively longer geographic distance from the central market (Addis Ababa), which is about 561 km. The geographic distance and quality differences between the central market and local market create differences in the magnitude of the equilibrium error correction coefficient, which increases the possibility of adjusting price in a shorter geographic distance.

The findings clearly show that price changes are not transmitted throughout the vertical system, at least not within the same period. Wholesale price increases are not always reflected in producer's prices, whereas producers' prices tend to adjust in response to higher wholesale prices. The study findings imply that banana spatial and vertical markets are imperfectly integrated into the long run due to market power and concentration at various stages of supply chains, which can be the causes of asymmetric price transmission (Shikur *et al.*, 2020, Habte *et al.*, 2016). The wholesale marketing system provides an opportunity for wholesalers to exercise market power that leads to asymmetric price transmission. This can be caused by several factors, such as transport and transaction costs, market power, adjustment costs, and domestic policies (Abdulai, 2002). The geographic boundaries of a market are important in determining supply and demand, setting prices, and determining the competitive structure. Market integration information may provide specific evidence of market competitiveness, arbitrage effectiveness, and pricing efficiency (Abdulai, 2000). The study found asymmetries for the banana market reflecting the existence of non-competitive banana markets due to distinctive market characteristics such as geographic distance and deficient infrastructure. The study suggests poor physical infrastructure, longer geographic distance, search costs, and imperfect competition as causes of price information asymmetries in banana supply chains, as suggested by Habte (2016).

Table 3: Spatial Price Transmission in The Banana Supply Chain

Variable	*Arba Minch*	*Tepi*
	Coefficient	*Coefficient*
Arba Minch/Tepi producer price (LR)	-0.16 (0.17)	-0.23 (0.47)
Arba Minch retail price (LR)	-0.37 (0.11)	0.14 (0.20)
Tepi retail price (LR)	0.14 (0.17)	0.33 (0.36)
Addis Ababa retail price (LR)	0.07 (0.07)	0.05 (0.15)
Addis Ababa wholesale price (LR)	0.34**(0.13)	0.39**(0.15)
Arba Minch/Tepi producer price (SR) (D1)	0.09 (0.14)	-0.14 (0.13)
Arba Minch retail price (SR) (D1)	0.01 (0.07)	-0.06(0.07)
Tepi retail price (SR) (D1)	-0.05 (0.15)	-0.22 (0.15)
Addis Ababa retail price (SR) (D1)	-0.07(0.13)	0.18 (0.13)
Addis Ababa wholesale price (SR) (D1)	0.17* (0.09)	0.37**(0.14)
Adjustment (ECT)	-0.70***(0.14)	-0.37**(0.11)
Constant	1.93***(0.57)	0.48 (0.57)
Diagnostics Test	Normality Test (χ^2_n)	
Hetroskedasticity test (χ^2_{ht}) = 0.59 (0.16)	JB=8.54 (0.04)	
Serial correlation test (χ^2_{sct}) = 7.61(0.20)	Kurtosis 8.31	

Notes: Values of standard errors are in parentheses. ***, **, *, denotes significance at the 1%, 5%, and 10% levels, respectively.

Source: Author's calculations based on Ethiopian CSA databases (2022).

The findings showed that there was an insignificant short- and long-run relationship between banana producers' prices in surplus areas and retailers' prices in deficit areas. The negative ECM coefficients (-0.70 and -0.37) indicated that the price equilibrium was stable with moderate and low speed of adjustments (Table 3). The geographic distance and quality difference between the central market and the local market contribute to the magnitude of the equilibrium error correction coefficient. The higher the possibility of adjusting prices becomes, the shorter the geographic distance, probably due to lower transportation costs incurred during marketing activities (Shikur, 2023).

4.4. Results of the Granger Causality Tests

Table 4: Results of the Granger Causality Tests

Variable	*Df(lags)*	*F-statistics*
Arba Minch producer price led Addis Ababa wholesale price	2	3.10* (0.08)
Addis Ababa wholesale price led Arba Minch producer price	2	4.93** (0.05)
Arba Minch retail price led Addis Ababa wholesale price	3	0.13 (0.73)
Addis Ababa wholesale price led Arba Minch retail price	3	0.11 (0.78)
Tepi producer price led Addis Ababa wholesale price	4	3.90** (0.04)
Addis Ababa wholesale price led Tepi producer price	4	7.05*** (0.00)
Addis Ababa wholesale price led Tepi retail price	2	5.36** (0.02)
Tepi retail price led Addis Ababa wholesale price	2	0.05 (0.81)
Arba Minch retail price led Tepi retail price	2	3.10 (0.08)
Tepi retail price led Arba Minch retail price	2	3.43* (0.06)
Arba Minch retail price led Addis Ababa retail price	3	0.78 (0.53)
Addis Ababa retail price led Arba Minch retail price	3	0.65 (0.67)
Tepi retail price led Addis Ababa retail price	2	0.60 (0.81)
Addis Ababa retail price led Tepi retail price		
Arbaminch retail price leading Addis Ababa retail price	2	7.60*** (0.00)

Notes: The values of probability are in parentheses. ***, **, *, denotes significant at the 1%, 5%, and 10% levels, respectively. The lag length is selected on the basis of the Akiake Information Criteria and F-test considering a maximum lag of four.

Source: Author's calculations based on Ethiopian CSA databases (2022).

The existence of Granger causality was tested between pairs of banana market prices. The findings in Table 4 indicate that there was bidirectional causality between Arba Minch banana producers' and central wholesalers' prices. There was a feedback causal relationship between Tepi producer price and Addis Ababa wholesaler price, which was consistent with the work of Fatin *et al*. (2020). The Addis Ababa wholesale mark*et al*so had unidirectional relationships with Tepi retailer markets at the 5% level. The findings were consistent with those of Worako (2015). This implied that the Tepi retail market relied on central wholesale market price information to set its price. However, the Addis Ababa banana retail market did not depend on Arba Minch and Tepi retail prices to fix its prices. The results indicate that wholesale traders in the central market had more power in price formation than retailers and producers (Table 4).

The empirical findings in Table 4 show the causal directions running from Addis Ababa wholesale prices to Arba Minch and Tepi producer prices. In Ethiopia, changes in Addis Ababa wholesale prices have a significant impact on producer prices. The findings are consistent with the work of Getnet *et al*. (2005), who confirmed that central markets determine the long- and short-run producers' prices in the supply chain. This implies that market structures are non-competitive since producer prices are dominantly influenced by traders. Farm-gate prices fall as a result of a lack of competition, distorting producer incentives, and undermining banana productivity. Farmers can only combat this situation by forming associations or cooperatives that market their products on their behalf. This implied that there was more concentration of market power at the wholesalers' level than at the producers' level. It is possible to conclude that wholesale traders determined market prices when purchasing from producers in local markets and when selling to retailers in the central market.

5. Conclusions and Policy Implications

A better understanding of price transmission in the banana supply chain in Ethiopia can simulate banana production and encourage actors to produce and supply more products in the supply chain that could enhance their income level. Knowledge about the behaviour of spatial and vertical markets can be employed as an information source for targeting potential policy interventions to improve the performance of banana markets and alleviate price fluctuations to stabilise income.

The results showed the existence of market integration and price transmission among actors in the supply chain. The significance of the elasticity coefficient of the wholesale price (-0.71, -0.33) suggested that there was a considerable degree of vertical price transmission from the central wholesale market to the local producer markets, indicating market integration. The wholesalers' prices in the deficit area played a significant role as a short- and long-run determining factor of banana prices in the surplus areas.

Granger causality test results showed that there was unidirectional causality running from wholesale markets to Arbminch producer's markets and bidirectional causality between wholesale markets and Tepi producer markets. The results indicated that Addis Ababa banana wholesale markets were the leading markets followed by banana producer and retail markets in terms of price formation. This implied that wholesale prices were important determinants of retail prices in consumer markets and of producer prices in local markets. The results of this study implied that any imperfect market in wholesale markets adversely affected followers. To overcome these constraints and enhance the role of wholesale markets in the efficient distribution of bananas, there is a need to provide more statutory autonomy and dynamic management. This will enable banana markets to evolve into true service centers for the marketing sector, offering services such as market information and technical support, while also ensuring the implementation of effective operating rules and regulations.

In general, few traders in the banana supply chain set banana prices by establishing a strong network from the farm gate to retail markets. Therefore, stockholders should either form or strengthen existing producers' cooperatives that enable them to break the trader network and increase market power. Implementing proper pricing policies to correct banana market imperfections has great positive implications for banana production and productivity, banana market development, and producers' and consumers' welfare. This intervention could improve flows of goods and information to benefit producers by securing a proper share of the final prices by facilitating faster price transmission along the banana supply chain, which could also maintain banana prices lower at the retail level to save consumers against significant price increases.

Continuous awareness-raising is required to encourage farmers to organise and join cooperatives that could take over the roles of travelling traders/banana collectors in the study area. Banana cooperative management members must receive more training and advice on business management and market linkage to improve bargaining power, improve market linkage, and provide farmers with up-to-date and consistent market information. Farmers should have access to a well-coordinated, up-to-date, and reliable market information delivery service that includes product price and quality. To summarise, governments and non-governmental organisations should devote sufficient attention to addressing constraints throughout the chain to create a sustainable banana value chain.

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Appendix Figure

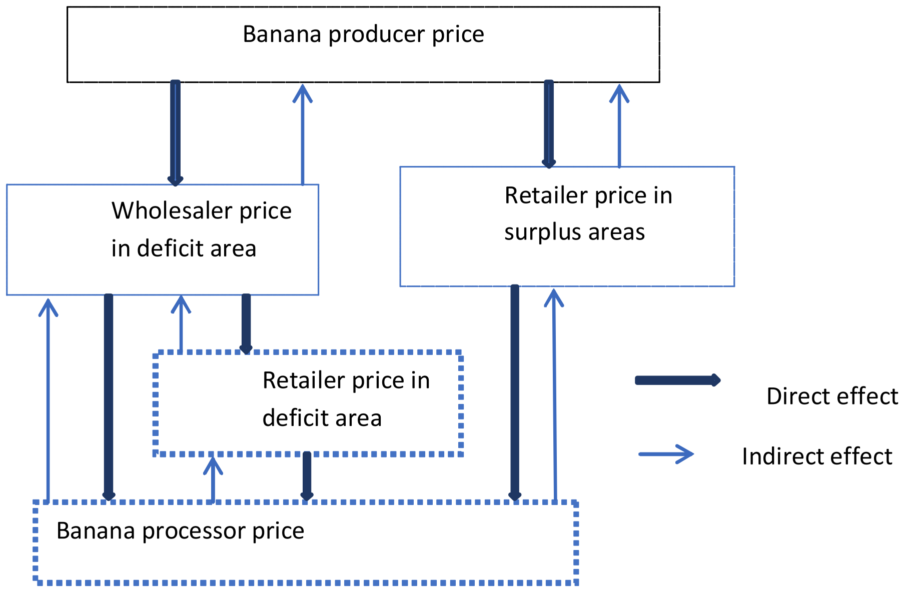

Figure 1: Shock transmission along the banana supply chain in Ethiopia

Appendix Table 1: Augmented Dickey– Fuller (ADF) Test of Variables with and without Constant (H0: Unit Root)

Variable	*Constant*		*Without constant*	
	T value		*T value*	
	Level	*FD*	*Level*	*FD*
Arba Minch producer price (APP)	-4.30***	11.97***	-5.35	-10.01***
	(0.00)	(0.00)	(0.00)	(0.00)
Tepi producer price (TPP)	-2.29	6.23***	-0.46	-4.11***
	(0.18)	(0.00)	(0.59)	(0.00)
Addis Ababa wholesale price (AAPW)	-2.78	-6.76***	-1.02	-5.57***
	(0.02)	(0.00)	(0.75)	(0.00)
Arba Minch retail price (ARP)	-3.80***	-6.76***	-3.92**	-6.00***
	(0.20)	(0.00)	(0.04)	(0.00)
Tepi retail price (TRP)	-1.6	8.89***	-0.46	-7.31***
	(0.48)	(0.00)	(0.59)	(0.00)
Addis Ababa retail price (AARP)	-0.61	4.89***	-0.76	-4.55***
	(0.98)	(0.00)	(0.49)	(0.00)

Notes: FD stands for the first difference. Values of probabilities are in parentheses. The T value is the test statistic from the Augmented Dickey– Fuller test; an optimal lag length is determined with the help of the Akiake Information Criteria and F-test assuming a maximum lag of four; ***, **, *, denote rejection of the null hypothesis of non-stationarity at the 1%, 5%, and 10% levels, respectively.
Source: Author's calculations based on Ethiopian CSA databases (2022).

Appendix Table 2: Results of the ARDL Bounds Test for Co-Integration

Dependent variable	*F-statistic*	*Decision*
APP/ AAPW, AAPR	5.56***	Co-integration
TPP/ AAPW, AAPR	4.75***	Co-integration
AAWP /APP, AAPR	3.21	No
AAWP /TPP, AAPR	4.56***	Co-integration
AAPR/ APP, AAPW	3.35**	Co-integration
AAPR /TPP, AAPW,	2.11	No co-integration

Arba Minch producer price (APP), Tepi producer price (TPP), Arba Minch retail price (ARP), Tepi retail price (TRP), Addis Ababa wholesale price (AAPW), and Addis Ababa retail price (AARP). For instance, the value of co-integrated variables for equation (1): Fap (APP/ AAPW, AAPR) = 5.56; for equation (2): Ftp (TPP/ AAPW, AAPR) = 4.75.

Notes: ** and *** significance at 5% and 1 % levels, respectively. The lower-bound and upper-bound critical values are 3.23 and 4.35 at 5%, respectively. The lower-bound and upper-bound critical values are 4.29 and 5.61 at 1%, respectively. Regarding the lower critical bound, it is assumed that all variables are I (0) (no co-integration among variables), and regarding the upper critical bound, it is assumed that all variables are I (1) (co-integration among variables).

Source: Author's calculations based on Ethiopian CSA databases (2022).