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Price Linkages Between Tea Markets: A Case Study for Colombo, Kolkata and Mombasa Auctions

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Abstract:

Purpose: *This paper aims to identify the price linkages among the three largest auction tea markets in Colombo (Sri Lanka), Kolkata (India), and Mombasa (Kenya). The hypothesis about the existence of long-term price linkages between markets was verified and the rate of short-term price reactions to exogenous price shocks on particular markets has been defined.*
Design/Methodology/Approach: *Due to a diverse level of integration of particular variables, ARDL models were applied in the analyses. The bounds test was applied to test long-term price linkages. Short-term adjustment were described based on the restricted Error Correction Models.*
Findings: *The obtained results indicated that market linkages were mainly long-term. Short-term price linkages among markets were poor. The Colombo market had the largest number of price maker features, but the Kolkata market behaved more like a price taker. The article analyzes average prices of tea in the individual markets. Price differences do not include the tea class quality.*
Practical Implications: *The results indicate that price information on other markets is primarily relevant for long-term decisions. In short-term decisions, information on tea prices on other markets is of relatively small importance.*
Originality/Value: *The indication of central markets is important for market participants. It is difficult to determine a priori whether and if so which markets are the most important in the price setting process. The obtained results indicate that the Colombo market was the leading market in the long term. In the short term, price information on other markets was primarily relevant for the Kolkata market.*

Keywords*: Tea, auctions, price linkages.*

JEL Codes: *Q27, Q31, F14, F17.*

Paper type: *Research article.*

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1. Introduction

Price linkages are deemed crucial for testing market integration (Baulch, 1997; McNew, 1996; Yang, Hwang and Huang, 2002). Integrated markets are the markets where prices are not independent. Price changes on one market are accompanied by price changes on another market, although this change does not have to be equivalent. Integrated markets should demonstrate long-term price linkages, while in a short term these links may be weaker. In the price discovery process, the market structure, methods of transactions and determining their conditions, as well as a type of goods are significant (Carlberg and Ward, 2003). Auctions constitute one of popular forms on the market of agricultural products (Banker and Mitra, 2007; Valiante and Egenhofer, 2013). While ensuring strong transparency and fast communication, they may increase efficiency of markets, especially those characterised with a wide product diversity.

In the paper, prices on three tea auctions were analysed. Tea constitutes an agricultural product for which the international market is very important. According to FAO, approx. 30% of global tea production is exported. In the past decades, this market has been characterised with a high growth dynamics. From 1991 to 2017, the global tea export increased from 1.2 million tonnes to 2.1 million tonnes, while the export value increased from USD 2.5 billion to USD 8.0 billion. The international tea market is affected by a strong concentration of production. Due to the soil and climatic requirements, tea is grown only in some regions of the world in tropical and subtropical areas, mainly in developing countries of Asia and Africa (Chang, 2015).

In these regions, tea plantations are important for agricultural production, food and agriculture sector, labour markets, and the domestic transport (Gunathilaka and Tularam, 2016; Alkan, Koprulu and Alkan, 2009). Strong concentration of production is accompanied by a strong concentration of global export. Over 80% of global crops and more than 70% of a value of global export falls on the largest five producers (China, India, Kenya, Sri Lanka, Vietnam). Global import is more diversified. The largest importers include Pakistan, Russia, USA, Great Britain and United Arab Emirates, with more than 30% of a value of global import.

The international market of tea, just like coffee and cocoa, is described with a significant share of re-export in global turnover. The largest re-exporters include United Arab Emirates, Germany, Great Britain, USA, and Poland. The international tea market is captured by large international concerns (Vickner and Davies, 2002). Together with a strong spatial concentration of trade, it favours the integration of regional tea markets, including price linkages between them (Gunathilaka and Tularam, 2016; Paul, 2008). A strong product and qualitative segmentation constitutes the factor that weakens linkages between regional markets (Tanui, Fang, Feng, Zhuang and Li, 2012). Basically, we distinguish a black, green, white, and red tea. However, each of these types has many categories connected with qualitative features, while differences in prices of extreme qualitative categories may come to thousands percent.

This paper aims at the identification of price linkages among three largest auction tea markets in Colombo (Sri Lanka), Kolkata (India), and Mombasa (Kenya). These markets belong to the most important ones for the international tea market. Contrary to the Chinese market, they consist in auctions, as this feature increases their price transparency. Colombo and Mombasa are the largest tea auctions in the world, while Colombo aggregates supply from Sri Lanka and on Mombasa auctions tea from neighbouring countries is also sold (Burundi, Rwanda, Tanzania, Uganda). In turn, the Kolkata market is the largest Indian tea auction, right next to Guwahati. On the Colombo auction, transactions are concluded on Tuesday and Wednesday, while price reports are drawn up for three quality standards: high, medium, low elevations and on average for all of them. On the Kolkata auction, transactions are concluded on Monday and Tuesday (or Wednesday). It is an electronic auction. On the Mombasa auction, transactions are concluded on Monday (second grades) and Tuesday (main grades).

Within the framework of conducted analyses, the hypothesis about the existence of long-term price linkages between markets was verified and the rate of short-term price reactions to exogenous price shocks on particular markets was defined. Based on the obtained results, one attempted to state, as well, whether the studied markets were equal to each other, or whether some of them occupied a central or peripheral place.

2. Literature Review

Prices constitute the basic economic category, that is why they constitute the subject of numerous analyses (Fackler and Goodwin, 2001; Valiante and Egenhofer, 2013; Bekkers, Brockmeier, Francois and Yang, 2017; Thalassinos and Pociovalisteanu, 2007). One of interesting directions of research in this area refers to their transmission (Bekkers *et al.*, 2017; Greb, Jamora, Mengel, Cramon-Taubadel, Wurriehausen, 2016; Rembeza and Seremak-Bulge, 2009). Under this direction of research, the subject of interest is usually constituted by the processes of transmission of price impulses, directions of their flow, and disturbances in transmission processes.

Price is basically an equivalent for the purchase of specific goods. The function connected with the information transmission constitutes the basic function performed by prices in economy (Bhuyan, Robbani, Talukdar and Jain 2016; Friedman, 2007; Thalassinos *et al.*, 2015; Ugurlu *et al.*, 2014). An analysis of prices at consumers makes them choose an optimal basket of goods at a given income, while at enterprises – it makes them decide on the production volume and on the applied technology. While making a choice, consumers follow utility maximization, while manufacturers – profit maximization. Therefore, the issue of making price-related decisions in enterprises constitutes the main economic problem of its functioning. When making choices, prices should ensure a proper balance on all partial markets and in the entire economy (Chiang, 1994; Varian and Harris 2014), while the speed at which balance is achieved depends on the price response. Classic models are based on the assumption of full flexibility of prices and wages in economies. Keynesian models assume their incomplete elasticity. In economic analyses, particularly at the macro level, the most general assumptions as to the price establishment method are adopted. However, the price level is largely affected by the institutional and legal environment, among others tax system or economic policy of the state, e.g. with regard to foreign trade.

Currently, economies operate in the international environment and price responses on one (domestic) market result in price changes on another (domestic, international) market. This process is defined as the price pass-through or price transmission. Price relations were observed in the past, firstly on crop markets (Nazlioglu, 2019; Aguiar and Santana, 2002) and on liquid fuel markets (Leszkiewicz-Kędzior, 2011; Kaufmann and Laskowski, 2005; Roberts, 2019). Together with an increasing level of integration of domestic and international markets, the phenomenon of price relation became an interesting research area.

The basic balance model describing the mechanism of price formation on particular markets is constituted by the model considering the action of the law of one price – LOP. According to the LOP assumptions, prices of the same products on two distinct markets cannot differ more than costs of product transfer between markets. Price arbitration is a mechanism triggering price equalization between markets. It is conducted so long as prices on related markets stand at the level reducing marginal profits from this activity to zero. A change in supply and demand conditions results in the start of arbitration and adjustment of prices on related markets to new conditions. Thereby, price shocks are transferred between related markets and there occurs the transition from one state of balance to another. The LOP assumptions constitute the basis for models describing the mechanism of price relations between markets (Samuelson, 1952; Dukhanina and Massol, 2018; Galay, 2018).

The law of one price is applied in reference to price transmission in three dimensions: transmission in space, transmission in time, and transmission of prices within the framework of vertically integrated markets. Space results in distortions on a perfectly competitive market, as well as affects relations between supply and demand. It causes the reduced price flexibility on selected markets, even geographic price discrimination (Enke, 1942). In the case of zero costs of transfer between markets, spatial arbitration should result in the price equalization on markets and in consistent price responses on related markets. In the case of positive transfer costs, prices may behave independently, within the range determined by these costs. A wider range of transfer costs may result in a stronger price response.

Transport costs constitute the most important item of transfer costs. That is why it should be expected that the larger the distance between markets, the weaker the price transmission between them. Space is not the only factor disturbing and limiting the price transmission, as they include also limitations in trade between markets, risk in transfer of products, imperfect and incomplete information. An increasing level of integration in global economy, gradual limitation of barriers and liberalization of international trade result in the reduction of changes in price levels among countries – prices on domestic markets are similar to the global level. The model of price transmission over time takes into account the product storage cost, considering actual storage costs and alternative costs, i.e. interest rates that constitute an element of time bonus.

More complex connections are examined by models of price transmission within the framework of vertically integrated markets. Price relations on various market levels, e.g. among prices of raw materials, semi-finished and finished products result from the fact that raw materials and semi-finished products constitute an element of production of final goods. Changes in prices of raw materials may be interpreted as a signal of changes in aggregated demand. An increase in demand for final goods increases the demand for raw materials and semi-finished products, which may trigger an increase in their prices. Even if prices are changing simultaneously on both markets, the response on the market of raw materials reaches its participants faster.

Usually the mechanism of price relations between markets refers to the assumptions of a competitive market, just like the law of one price. However, markets on which sellers and buyers are functioning are spatially diversified, undergo various fluctuations in time, while costs of transport are relatively high – these factors challenge the assumptions of the competitive market model. These markets function usually as oligopolistic markets, so price relations in space are better described by the model of base price or oligopolistic competition (Faminow and Benson, 1990; Torshizi and Gray, 2017). In the case of the base price model, the point of reference for price structure in space is constituted by the base price which, after the consideration of transport costs, specifies the price level in other points of space. On oligopolistic markets, a price change on one market triggers the sequence of responses and feedbacks and, as a consequence, the establishment of a new price level.

Price arbitration performs the basic role in the transmission mechanism. However, in practice the process of price transmission between markets is often different from theoretical models. The process of price transmission between markets involves numerous disruptions, due to which price responses are not equivalent and delayed – they cause the so-called asymmetric price transmission. Meyer and Cramon-Taubadel (2004) distinguished three types of price asymmetry, i.e. asymmetry of response scale, asymmetry of response time, mixed asymmetry. The asymmetry of response scale concerns the situation when an increase in prices on one market results in a price drop on another market. Usually this response is permanent. The asymmetry of response time manifests itself with an asymmetric distribution of price response in time on one market against price changes on another market.

Time of price response to price rises and drops on one market may be different on another market. The asymmetry of response time may refer to one response or to its series. Moreover, it is usually temporary, as it disappears after some time. The mixed asymmetry has features of both the asymmetry of response scale and the asymmetry of response time, as it combines temporary and permanent components. Another method of classification was offered by Peltzman (2000), who distinguished two types of asymmetry: positive and negative.

Market integration involves the flow of products, production factors, technologies, and information. It triggers a gradual liquidation of barriers between markets, standardization of a legal, political, cultural system. An example of integration may be constituted by the creation of free trade areas, economic unions. Generally, integration means the creation of a whole from parts, incorporation, and harmonization of elements creating a whole (Heytens, 1986; Awokuse, 2007). The integration process may occur in the spatial, time and vertical configuration (Parola and Veenstra, 2008). This classification is concurrent with the classification of price transmission. This fact indicates a close connection of market integration with the price transmission process. If markets are not integrated with each other, one should expect that prices on these markets shall not interact, because there is no mechanism ensuring price transmission between markets. Price arbitration is impossible between the markets that do not create a bigger, integrated whole.

Traditional measurements of market integration are based on data concerning trade volume, e.g. the ratio of import/export volume to the GDP value. However, inferring from it, one may reach an incorrect conclusion that economies with a low share of commercial exchange are less integrated with the global economy. Measurements based on the volume of exchange describe only one aspect of integration.

Similarly in a situation of two markets exporting products to the third market. As exporters of the same goods, they cannot trade with each other, but their market may be strongly integrated via the third market. An increase in prices on one market triggers an analogous increase in prices on the second market. In this case, the flow of information constitutes a substitute for the flow of products. That is why no physical trade between markets or its low activity may not be treated as an argument supporting the low integration of markets. Price behavior on both markets may be closely interrelated and a strong integration may evince in this relation.

Therefore, in many cases the market integration refers not only to the flow of products, but also to price behavior (McNew, 1996; Barret and Li, 2002). Price transmission provides with a lot of information connected with changes in a level of market integration, enables to look at integration processes from a different point of view than analyses of integration based on the volume of product flows.

3. Materials and Methodology

The analysis of linkages between prices is a common approach in testing the market integration (Barrett and Li, 2002). The existence of long-term relations between prices on particular markets is usually regarded as the confirmation of their integration (Hanias *et al.*, 2007). The VAR and ARDL models are commonly applied for the analysis of price linkages. The specificity of variables constitutes one of prerequisites for the selection of a research procedure. The condition for the VAR model application is constituted by the integration of all variables at the same level. This limitation does not concern the ARDL models (Pesaran and Shin, 1998). At the initial stage of the analysis, the occurrence of breakpoints in price series was determined. The Bai-Perron test was applied for that purpose (Bai and Perron, 1998). Then, integration tests with use of the ADF test and breakpoint unit root test were conducted (Perron and Ng, 1996). As results of those tests indicated that price series were integrated at various levels, the ARDL models were applied in the price linkage analyses. In its general version, the ARDL model for two price series P_x and P_y may be presented as follows:

$$P_{y,t} = \alpha_0 + \sum_{i=1}^{p} \alpha_i P_{y,t-i} + \sum_{i=0}^{q} \beta_i P_{x,t-q} + \varepsilon_t \qquad (1)$$

The above model may be extended with subsequent exogenous variables, including trend. A number of delays in the model was adopted based on the Schwartz criterion. Development of ARDL models requires a decision on the division into exogenous and endogenous variables. As the subject of the analysis was constituted by prices on three markets, three models were initially developed, where price on one market was treated as an endogenous variable, while prices on two remaining markets were treated as endogenous variables. In order to initially define relations between variables, the Toda Yamamoto causality tests, allowing for analysing variables at a various integration levels, were conducted (Toda and Yamamoto, 1995). Autocorrelation of residue components in models was verified with the LM test.

The bounds test (Pesaran, Shin and Smith, 2001) was applied to test long-term tea price linkages. This test is conducted based on the ARDL model converted into the unrestricted (conditional) Error Correction Models (ECM):

$$\Delta P_{y,t} = \alpha_o + \sum_{i=1}^{k} \alpha_i \Delta P_{y,t-i} + \sum_{j=1}^{p} \beta_j \Delta P_{x,t-j} + \theta_1 P_{y,t-1} + \theta_2 P_{x,t-1} + \epsilon_t \qquad (2)$$

Testing the long-term relation between variables is based on testing the H0 hypothesis that $\theta_1 = \theta_2 = 0$. Rejection of H0 means the acceptance of the hypothesis about long-term relations among variables P_y and P_x.

If the bounds test indicated long-term relations between variables, at the next stage short-term relations were analysed. To that end, the previously obtained ARDL models converted into the conventional restricted ECM were applied:

$$\Delta P_{y,t} = \alpha_0 + \sum_{i=1}^{k} \alpha_i \, \Delta P_{y,t-i} + \sum_{j=1}^{p} \beta_j \, \Delta P_{x,t-j} + \gamma z_{t-1} + \epsilon_t \qquad (3)$$

where z (error-correction term EC) is the residuals series from the long-run regression (so-called cointegration regression):

$$P_{y,t} = \alpha_0 + \alpha_1 P_{x,t} + z_t \qquad (4)$$

The γ coefficient from the model (3) indicates the rate of short-term price adjustments P_y to the long-term balance between P_y and P_x price. According to the theory, the γ coefficient should be negative.

In the paper, the World Bank data concerning average monthly tea prices for various types and quality classes were applied. Those prices were converted into the form of natural logarithms. The analysis covered the period from January 1991 to December 2018. Due to the occurrence of seasonal disorders, specific for every market, seasonally-adjusted prices with use of the Census X13 algorithm were used in the analyses.

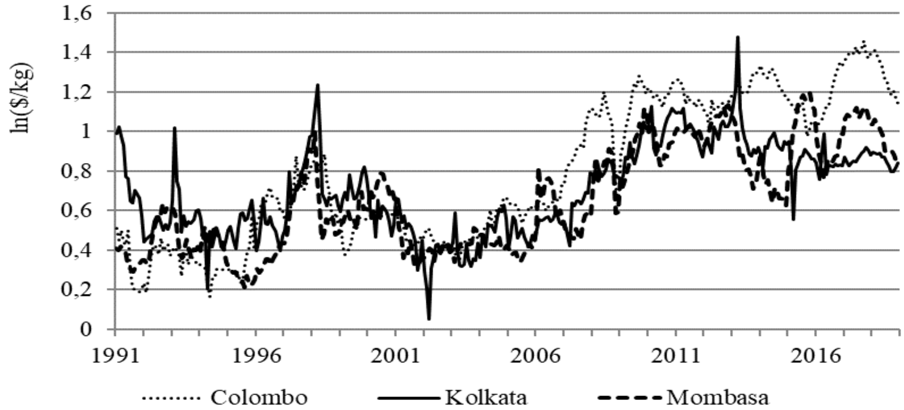
4. Results

In the analysed period, tea prices were marked by significant short- and long-term changes (Figure 1). In the first half of the analysed period, prices were demonstrating substantial fluctuations, without a clear trend of changes, while after 2005 they went into a distinct upward trend. Those changes were common for all three markets. However, prices on particular markets were diversified. In extreme cases, differences in price exceeded 30% and were rather unstable, particularly in the first half of the analysed period. After 2005 the highest tea prices were observed on the Colombo market, while differences between markets increased.

Price seasonality constitutes a typical phenomenon for the majority of agricultural product markets. It is usually conditioned by a seasonal nature of production. It is highly dependent on regional climatic circumstances. The studied markets demonstrated large differences with regard to the distribution, and in particular to the value of seasonal price changes (Figure 2). An average seasonal price deviation came to 10.5% in Kolkata, 2.8% in Colombo, and 1.8% in Mombasa.

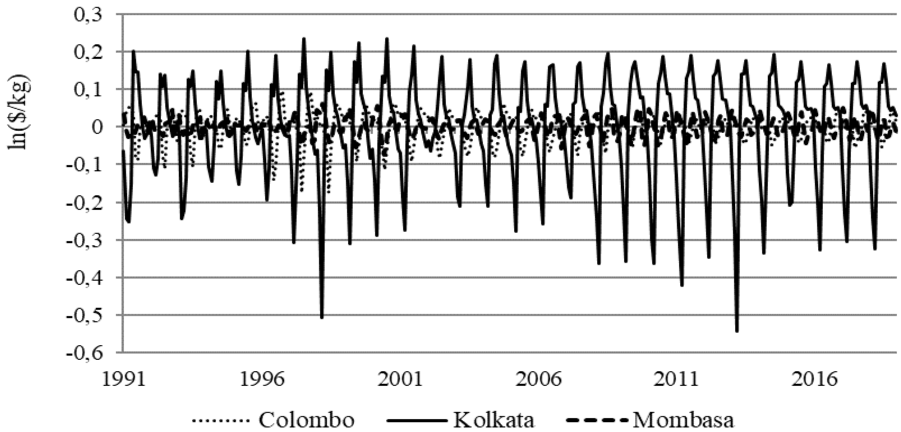
On the Kolkata market, the highest seasonal price falls, coming to 25-30%, were observed in July and August. On the Colombo market, seasonal falls happened usually in June and July. The Mombasa prices were subject to so minor seasonal fluctuations that it was practically hard to indicate months of significant price changes on that market. Seasonal price changes conditioned by local factors may significantly hamper analyses of market linkages, so in further analyses the seasonally-adjusted prices are applied.

Figure 1. *Tea auction prices*



Source: *Own calculation based on World Bank data.*

Figure 2. *Seasonal components of tea prices*



Source: *Own calculation based on World Bank data.*

According to the methodical comments, while identifying price linkages among markets, firstly the existence of long-term relations was tested, and in the case of their confirmation - the rate of short-term reactions. In the first step, breakpoints in time series were analysed. That analysis was conducted for two basic reasons. Firstly, determination whether time series include breakpoints provides with suggestions concerning testing a level of integration of variables. Secondly, breakpoints constitute specific points in time series connected with changes in trends. Table 1 presents break dates estimated for particular markets. The results show a significant compliance of break dates on the Kolkata and Mombasa markets. Differences between those markets did not exceed one month, which indicated a clear similarity in long-term price changes. The Colombo market was more specific. Break dates were shifted against other markets by many months, while in one case the difference came to almost two years. Every date of breakpoint on the Colombo market was preceded with break dates on the remaining markets. In other words, changes in price tendencies on the tea market occurred firstly on the Colombo market, which might indicate its particular significance for the international market.

Table 1. *Estimated break dates for tea prices (Bai-Perron test)*

Prices	Dates
Colombo	1995 M11, 2000 M06, 2007 M03, 2012 M12
Kolkata	1997 M03, 2001 M05, 2007 M12, 2014 M11
Mombasa	1997 M02, 2001 M04, 2008 M01, 2014 M11

Source: *Own calculations.*

A more accurate analysis of price linkages was conducted with use of autoregressive models. According to the methodical comments, the model type selection depends, among others, on the characteristics of variables, including the level of their integration. Therefore, in the next step a level of integration of the variables was tested. Table 2 presents results of tests not considering and considering breaks in time series. Results for two different tests provided with similar effects. They indicated that the Colombo prices constituted I~1 variables and the Kolkata prices - I~0. The Mombasa prices could be considered the I~0 variable only at the level of significance 0.1. Therefore, the results of integration tests confirmed the possibility of using the ARDL models and did not provide with reasons to use the VAR models.

Table 2. *Unit root tests for tea prices*

Prices	I~0		I~1	
	intercept	intercept and trend	intercept	intercept and trend
ADF				
Colombo	-1.1712	-2.9001	-17.7471[c]	-17.7195[c]
Kolkata	-3.5070[b]	-4.6360[c]	-13.5849[c]	-13.5869[c]
Mombasa	-2.0206	-3.4496[a]	-16.1114[c]	-16.0880[c]
Break point unit root test				
Colombo	-3.8130	-4.0510	-18.3022[c]	-18.3705[c]
Kolkata	-6.1274[c]	-6.1339[c]	-20.7674[c]	-20.7258[c]
Mombasa	-4.5756[a]	-4.3902	-17.1963[c]	-17.1270[c]

Source: *Own calculations.*

In the analysis of price linkages, particularly at the initial stage, causal links were tested. As particular variables were integrated at a various level, the Toda Yamamoto procedure was applied. In the case of the pair of variables I~0 and I~1, it consists, firstly, in the development of conventional VAR models with an optimal number of delays, and then in the introduction of another delay in variables as exogenous variables. For VAR models obtained in such a way, causality tests were performed in the paper. Table 3 presents results of those tests. They indicate that causal links are the most noticeable between the Mombasa prices as the reason and the Kolkata prices, as well as between the Mombasa prices as the reason and the Colombo prices. Linkages between the Colombo prices as the reason and the Kolkata and Mombasa prices were less significant. Test results clearly indicated that the Kolkata prices were not the reason for the Colombo and Mombasa prices.

Table 3. *Granger causality test for tea prices (Toda-Yamamoto procedure)*

Dependend variable	Excluded variables	Wald test	
		χ^2	prob.
Colombo	Kolkata	0.0354	0.8508
	Mombasa	3.3282	0.0681
	All	3.3810	0.1844
Kolkata	Colombo	2.6127	0.1060
	Mombasa	6.2545	0.0124
	All	10.8124	0.0045
Mombasa	Colombo	1.9161	0.1663
	Kolkata	0.0964	0.7562
	All	2.0692	0.3554

Source: *Own calculations.*

In the next step of the analysis, ARDL models were developed for particular markets (Table 4). On all markets, current tea prices were affected by prices from their own markets and from other current and/or delayed prices on other markets. The Colombo prices were affected by the Kolkata prices, the Kolkata prices were affected by the Colombo and Mombasa prices, while the Mombasa prices - by the Colombo prices. Test results indicated the lack of residue autocorrelation, which was the condition for further analyses concerning long- and short-term relations between variables.

Long-term linkages between tea prices on particular markets were analysed with use of bounds test. The table 5 presents the F test values and critical values for selected levels of significance for the lower and upper limit. The lower bound is based on the assumption that all variables are I(0), while the upper bound is based on the assumption that all variables are I(1). The obtained results confirmed the occurrence of long-term linkages between tea prices on the studied markets. In the case of models for the Kolkata and Mombasa prices, long-term linkages were significant at the level of 1%. In the case of models for the Colombo prices, long-term linkages were significant at the level of 5%, while for the level of 2.5% results did not provide with an unambiguous answer (test values were between those specified for I(0) and I(1)).

Table 4. *ARDL models, conditional Error Correction Models and cointegrated relationships for tea price*

Colombo - Clb			Kolkata - Klk			Mombasa - Mmb		
variable	coeff.	p-value	variable	coeff.	p-value	variable	coeff.	p-value
ARDL models:								
						Mmb (-1)	1.0289	0.0000
Clb (-1)	0.9766	0.0000	Klk (-1)	0.7162	0.0000	Mmb (-2)	-0.1266	0.1128
Clb (-2)	0.0409	0.5968	Clb	0.1475	0.0000	Mmb (-3)	0.1104	0.1664
Clb (-3)	-0.1138	0.0388	Mmb	0.0102	0.8931	Mmb (-4)	-0.0282	0.7230
Klk	0.5310	0.0148	Mmb (-1)	0.1318	0.0885	Mmb (-5)	-0.0943	0.0811
C	-0.0028	0.7613	C	0.0558	0.0001	Clb	0.2023	0.0009
Trend	0.0003	0.0002	Trend	-0.0004	0.0002	Clb (-1)	-0.1351	0.0237
						C	0.0202	0.0140
Adj. R^2	0.9824		Adj. R^2	0.8886		Adj. R^2	0.9593	
LM test[1]	0.5739		LM test[1]	0.7958		LM test[1]	0.5661	
BPG test[1]	0.0813		BPG test[1]	0.0488		BPG test[1]	0.7587	
Conditional Error Correction Models:								
Clb (-1)	-0.0963	0.0001	Klk (-1)	-0.2838	0.0000	Mmb (-1)	-0.1099	0.0000
Klk	0.0530	0.0148	Clb	0.1475	0.0000	Clb (-1)	0.0671	0.0000
dClb (-1)	0.0729	0.1845	Mmb (-1)	0.1421	0.0000	dMmb (-1)	0.1387	0.0098
dClb (-2)	0.1138	0.0388	dMmb	0.0102	0.8931	dMmb (-2)	0.0122	0.8209
C	-0.0276	0.7613	C	0.0558	0.0001	dMmb (-3)	0.1226	0.0230
Trend	0.0003	0.0002	Trend	-0.0004	0.0002	dMmb (-4)	0.0942	0.0811
						dClb (-1)	0.2023	0.0009
						C	0.0212	0.0140

Source: *Own calculations.*

Table 5. *Long-term relationships for tea prices – bounds tests for conditional Error Correction Models*

Test	Colombo[1]	Kolkata[1]	Mombasa[1]	Critical values		
				Significance	I(0)	I(1)
F-Bounds test (F-statistic)	5.5241	17.5831	12.4548	10%	4.05	4.49
				5%	4.68	5.15
				2.5%	5.3	5.83
				1%	6.1	6.73

[1] – F-statistic

Source: *Own calculations.*

From the obtained ARDL models, there was delivered the levels equation for conditional Error Correction Models, presenting long-term price reactions between particular markets. These equations are presented below (in brackets the standard deviations for particular coefficients):

- Colombo

$$EC = Clb - (0.5504\ Klk + 0.0026 Trend)$$
$$(0.1568) \qquad (0.0004)$$

- Kolkata

$$EC = Klk - (0.5241\ Clb + 0.5003\ Mmb - 0.0014\ Trend)$$
$$(0.1060) \qquad (0.1048) \qquad (0.0003)$$

- Mombasa

$$EC = Mmb - (0.6108\ Clb)$$
$$(0.0743)$$

The presented equations indicate that in the long term an increase in the Kolkata prices by 1% has resulted in an increase in the Colombo prices by 0.55%. An increase in the Colombo and Mombasa prices by 1% has resulted in an increase in the Kolkata prices by, respectively, 0.52% and 0.50%. In turn, an increase in the Colombo prices by 1% has resulted in a long-term increase in the Mombasa prices by 0.61%.

Therefore, the obtained results indicate that long-term changes in the Colombo and Mombasa prices were not fully equivalent to other markets, although the very fact of existence of long-term linkages was confirmed. It means that the occurrence of a price shock on one market starts the short-term adjustment mechanism on another market. Those adjustments were described based on the restricted Error Correction Models (Table 6). The adjustment rate is described with coefficients for EC(-1). According to the theoretical assumptions, signs for those coefficients were negative but showed large differences. A relatively quick adjustment in response to exogenous price shocks was observed on the Kolkata market. On that market, the price gap developed as a result of exogenous price shocks by 1% was reduced during one month by 0.28%. A slower adjustment rate was stated for the Mombasa market, while the slowest one - for the Colombo market. Models presented in Table 6, though, explained only a small part of short-term price variability on particular markets. It indicates relatively weak short-term price linkages between particular markets.

Table 6. *Restricted Error Correction Models for tea prices*

Colombo			Kolkata			Mombasa		
variable	coeff.	p-value	variable	coeff.	p-value	variable	coeff.	p-value
dClb(-1)	0,0729	0,1831	dMmb	0,0102	0,8889	dMmb(-1)	0,1387	0,0097
dClb(-2)	0,1138	0,0381	EC(-1)	-0,2838	0,0000	dMmb(-2)	0,0122	0,8204
EC(-1)	-0,0964	0,0001	C	0,0554	0,0000	dMmb(-3)	0,1226	0,0227
C	-0,0251	0,3815				dMmb(-4)	0,0943	0,0805
						dClb	0,2023	0,0008
						EC(-1)	-0,1099	0,0000
						C	0,0202	0,0000
Adj. R^2	0,0452		Adj. R^2	0,1726		Adj. R^2	0,1220	

Source: *Own calculations.*

5. Conclusions

In the paper, tea prices on three largest tea auctions were analysed. It was attempted to determine whether those prices indicated long- and short-term linkages and whether some of them is central. A strong transparency of auction markets should favour the price transmission among markets. However, a wide product variation may constitute a weakening factor. As a consequence, teas with various quality levels and coming from various plantation regions do not have to be fully substitutes. The analysis results show that on the tea market we have to do with price linkage processes and with their specific conditioning on particular markets. As a result, price linkages on particular markets were mainly long-term. Short-term linkages were weak. Distinct specificity concerned in particular seasonal price changes.

The obtained results indicate that apart from impulses from its own market, the Colombo prices were affected by the Kolkata prices, the Kolkata prices were affected by the Colombo and Mombasa prices, while the Mombasa prices - by the Colombo prices. However, it is difficult to say without doubt what directions of price flows among the analysed markets were and it is difficult to determine whether any of them was central. The Colombo market demonstrated the largest number of features of a price maker. Breaks on that market were preceded with breaks on two other markets, while features on that market constituted a significant variable in the levels equation for conditional Error Correction Models for two remaining markets. In turn, the Kolkata market demonstrated more features of a price taker. It affected prices on other markets relatively poorly, while at the same time it responded the most strongly and the most quickly to price changes on those markets. Taking this into account, of the three analyzed markets, the most important are price changes on the Colombo market.

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