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HORIZONTAL MARKET INTEGRATION OF RUBBER AMONG SOME SELECTED MAJOR EXPORTING DEVELOPING COUNTRIES IN THE WORLD

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ABSTRACT

The research determined the horizontal market integration among the spatial major exporters of rubber *viz*. Ivory Coast, Indonesia, Philippines and Thailand in the world. Time series data from the FAO and UNCTAD data repositories that covered 51 years period (1966-2017) were utilized. The data were analyzed using descriptive and inferential statistics such as the unit root test, Johansen co-integration test and, restricted vector autoregressive (VAR) test. The empirical evidence showed presence of passive horizontal integration among the spatially separated markets. Compliance with the WTO policies makes the market prices of Ivory Coast to have effective linkages with the prices of all the selected markets; as trade war affected the price relationships between the latter markets *viz*. Indonesia, Philippines and Thailand; all situated in Asia. The market prices of Philippines and Thailand were not autarkic, thus the most efficient, as they are stable in the long-run and have the capacity to absolve any shocks that causes disequilibrium to its long-run equilibrium from any of the short-run. In addition, the market prices of Philippines and Thailand were more efficient as their prices were formed within the system while that of Ivory Coast and Indonesia depend on exogenous effect. The market prices of Thailand wield significant influence in price determination of rubber among the selected markets as the latter markets were relative follower in the international market. It was established that rubber marketing is useful in the international sphere as all the selected market prices witnessed persistent volatility. A high product quality will makes the market prices of Ivory Coast, Philippines and Thailand to be remunerative while poor quality coupled with sharp practices of oligopolistic middlemen will affect the market prices of Indonesia. Thus, the need for an effective marketing network that will enhance integration and efficient price communication among these markets is recommended.

Keywords: developing countries, integration, international, markets, prices, rubber

INTRODUCTION

When a product is traded on the global market, the price of a commodity in an integrated agricultural market is decided by supply and demand forces, and it reflects value in the integrated region or globally. The genuine worth of a commodity should prevail over geographically distinct marketplaces located in one or more nations under the one price rule, also known as the Law of One Price (LOP) (Lanfranco *et al*., 2019). The LOP can be used to assess a market's geographic extent and degree of integration within that market, as well as to identify and address areas where market integration has failed in the past. Short-run LOP anomalies can still occur, and they're caused by things like exchange rate fluctuations and other overshooting effects (Ardeni, 1989; Lanfranco *et al*., 2019).

Markets are dynamic and change frequently; yet, if they are allowed to function and act as a price signal throughout the integrated region, a single value level can emerge (Usman and Haile, 2017). Market integration and price transmission analyses are normally a burgeoning subject in the literature, with a number of research employing a variety of approaches (Darbandi, 2018). Price interaction analysis is beneficial since it leads to greater market recognition (Darbandi and Saghaian, 2016).

Market integration is a primary goal of regional trade blocs and multilateral trade agreements, and it is critical for regional and

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global economic development. The economic benefits of market integration have long been recognized as a compelling case for trade liberalization, and considerable global efforts have been made to reduce trade barriers, standardize laws and regulations, and promote goods and services trade. Market integration, or more precisely, penetration into global markets, is still a theoretical goal for many organizations and industries, and one that is frequently disrupted by stronger forces.

Price volatility is a common feature of agricultural markets, but extreme and sudden fluctuations in product pricing, referred to as price volatility, could be a source of concern for consumers, producers, and governments in developing nations (Sarris, 2013; Hassanzoy and Ito, 2018). Price fluctuation has a wide range of consequences, from worsening food insecurity and poverty to jeopardizing social and economic stability (Ceballos *et al*., 2017; Hassanzoy and Ito, 2018). Rubber is a valuable cash crop, yet there is little or no research on price transmission within or between regions. Therefore, it is in view of the foregoing that the research on horizontal market integration of rubber between some selected major exporting countries was conceptualized. The specific objectives of the study were to: described the price trends of the selected markets; determined the extent of market integration; determined the degree of market integration; determined how price formation takes place in each market; determined the effect of local shock on market prices; determined sources of price volatility; and, forecast the market prices of rubber in the selected markets.

Theoretical framework

Takayama and Judge (1971); Lanfranco *et al*. (2019) proposed a theoretical model based on the assumption that when information and commodities flow freely, the prices of a homogeneous good in two spatially distant markets should only fluctuate by transaction costs. If the price in one market is greater than the price in another market plus the transaction costs of transporting the product from the low-price market to the high-price market, there will be untapped pure profits.

Profits would incentivize rational traders to enter the market and exploit these arbitrage opportunities, reducing supply in the low-cost market while increasing supply in the high-cost market. Ceteris paribus, these two pressures will raise the price in the initially low-priced market while lowering the price in the higher-priced market. Price differentials between the two marketplaces finally equal transaction costs, and trade between the regions provides no expected arbitrage profits.

When two markets integrate entirely, price changes in the exporting zone produce price adjustments in the importing region in the same direction and amount. The extent and speed with which shocks are passed through, as well as the level of price interdependence, are used to determine the degree of integration and efficiency of the two markets' performance.

Cointegration analysis is used to determine the degree of market integration between physically disparate marketplaces. In economic terminology, two variables are cointegrated if they are in equilibrium or have a long-term relationship (Gujarati, 2003). The non-stationarity of most price series adds to the appeal of using these analytical tools to test for LOP. To put it another way, they expand throughout time and so lack a fixed 'stationary' mean (Kennedy, 1998). Cointegration theory allows for the analysis of long-run co-movement between or among economic variables in the context of non-stationarity.

RESEARCH METHODOLOGY

The current study used time series data from the FAO and UNCTAD data repositories, which covered the years 1966 to 2017. The data included market prices from the world's top rubber exporting countries, including Ivory Coast (IC), Indonesia (IND), the Philippines (PH), and Thailand (TH). Descriptive statistics were used to achieve objective I; unit root tests and the Johansen co-integration test were used to achieve objective II; and restricted VAR was used to achieve objective III. The Granger causality test was used to achieve objective IV; the restricted VAR impulse response function (IRF) was used to achieve objective V; and the GARCH model was used to achieve objective VI. The final objective was accomplished by employing restricted VAR to estimate price patterns in the chosen markets.

Empirical model

Augmented dickey fuller test

The autoregressive formulation of the ADF test with a trend term, as proposed by Sadiq *et al*. (2017), is as follows:

$$\Delta P_t = \alpha + P_{t-1} + \sum_{j=2}^{it} \beta_i \Delta P_{it-j+t} + \varepsilon \text{ ...... (1)}$$

Where, P_{it} is the price in market *i* at the time *t*, α and ΔP_{it} $(P_{it} - P_{t-1})$ is the intercept or trend term.

Johansen's co-integration test

The multivariate formulation is as follows, according to Johansen (1988):

$P_t = A_1 P_{t-1} + \varepsilon_t$ .... (2)

So that

$\Delta P_t = A_1 P_{t-1} - P_{t-1} + \varepsilon_t$ .... (3)

$P_t = (A_1 - 1)P_{t-1} + \varepsilon_t$

$\Delta P_t = \prod P_{t-1} + \varepsilon_t$

Where, P_t and ε_t are $(n \times 1)$ vectors; A_t is an $(n \times n)$ matrix of parameters; *I* is an $(n \times n)$ identity matrix, and $\prod$ is the $(A_1 - 1)$ matrix.

The tests for the number of characteristic roots that are insignificantly different from unity were conducted using the estimations of the characteristic roots and the accompanying data:

$\lambda_{trace} = -T \sum_{i=r+1}^{n} ln(1 - \lambda_i)$ .... (4)

$\lambda_{max} = -T\, ln(1 - \lambda_i + 1)$ .... (5)

Where *T* is the number of useable observations, and λ_i is the estimated values of the characteristic roots (Eigen-values) obtained from the calculated $\prod$ matrix.

Granger causality test

The model used to determine whether market P_1 Granger affects market P_2 or vice versa, according to Granger (1969), is as follows:

$P_t = \alpha + \sum_{i=1}^{n}(\emptyset P_{1t-i} + \delta_i P_{2t-i}) + \varepsilon_i$ .... (6)

To evaluate the Granger causality, a simple test of the joint importance of δ_i was used.

$H_0: = \delta_1 = \delta_2 = \ldots\ldots\ \delta_n = 0.$

Vector error correction model (VECM)

The VECM explains the difference between y_t and y_{t-1} (i.e.Δy_t) (Sadiq *et al*., 2016a; Sadiq *et al.*, 2016b):

$\Delta \gamma_t = \alpha + \mu(\gamma_{t-1} - \beta_{xt-1}) + \sum_{i=0}^{i=t} \delta_i \Delta x_{t-1} + \sum_{i=1}^{i=t} \gamma_i \Delta \gamma_{t-1}$(7)

It takes into account both *x* and *y* lagged differences, which have a more direct impact on the value of $\Delta \gamma_t$.

Impulse response functions

In the case of an arbitrary current shock (δ) and history(ω_{t-1}), the generalized impulse response function (GIRF) is as follows (Rahman and Shahbaz, 2013; Beag and Singla, 2014):

$GIRF_Y(h, \delta, \omega_{t-1}) = E[Y_t + h \mid \delta, \omega_{t-1}] - E[Y_{t-1} \mid \omega_{t-1}]$. (8)

Forecasting accuracy

Mean absolute prediction error (MAPE), relative mean square prediction error (RMSPE), relative mean absolute prediction error (RMAPE) (Paul, 2014), Theil's U statistic, and R^2 were used to calculate the accuracy of the fitted time series model:

$MAPE = 1/T \sum_{i=1}^{5}(A_{t-1} - F_{t-1})$ .... (9)

$RMPSE = 1/T \sum_{i=1}^{5}(A_{t-1} - F_{t-1})^2 / A_{t-1}$.... (10)

$RMAPE = 1/T \sum_{i=1}^{5}(A_{t-1} - F_{t-1})/A_{t-1} \times 100$.... (11)

$$U = \sqrt{\frac{\sum_{t=1}^{n-1} \frac{(Y_{t+1} - Y_{t+1})^2}{Y_t}}{\sum_{t=1}^{n-1} \frac{(Y_{t+1} - Y_t)^2}{Y_t}}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (12)$$

$$R^2 = 1 - \frac{\sum_{i=1}^{n}(A_{ti} - F_{ti})}{\sum_{i=1}^{n}(A_{ti})} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (13)$$

Where, R^2 = coefficient of multiple determination, A_t = Actual value; F_t = Future value, and T = time period

GARCH model

GARCH (*p, q*) representation is shown below:

$Y_t = \alpha + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \varepsilon_i$ ………..……(14)

(Autoregressive process)

And the variance of random error is:

$\sigma_t^2 = \lambda_0 + \lambda_1 \mu_{t-1}^2 + \lambda_2 \sigma_{t-1}^2$ ....(15)

$\sigma_t^2 = \omega + \sum_{i=1}^{p} \beta_i \sigma_{t-i}^2 + \sum_{j=1}^{q} \alpha_i \varepsilon_{t-i}^2$ ……… (16)

Where Y_t is the price in the i^{th} period of the market's i^{th}, *p* is the GARCH term's order, and *q* is the ARCH term's order. The sum of ARCH and GARCH $(\alpha + \beta)$ represents the degree of volatility persistence in the series. The nearer/closer is the sum to one; the more likely volatility will persist for a longer period of time. If the total is more than one, the series is explosive and has a propensity to meander away from the mean value.

RESULTS AND DISCUSSION

Summary statistics of the rubber market prices

A perusal of Table 1 showed the average prices of rubber to varied from \$415.37 to \$970.66 with the ebb and peak prices been observed in Philippine and Thailand markets. The minimum prices varied from \$56.59 in Indonesia market to \$227.88 in Thailand market; while the maximum price varied from \$958.96 to \$4066.70 respectively, in Indonesia and Thailand markets. It was observed that the price instability was high across all the selected rubber markets with the fluctuation rate been highest and lowest in Ivory Coast and Indonesia markets respectively. The heightened instability of Ivory Coast's rubber price may be attributed to high fluctuation in both the exchange rate and bridge in demand and supply. While the instability rate that plagued Indonesia market may be due to fluctuation between demand and supply for its rubber in the international market. Furthermore, an examination of the asymmetric distribution of the rubber market prices *viz*. skewness coefficient showed positive skewness associated with all the market prices. This is reasonable as rubber inventories cannot be negative, thus placed a positive skewness bias on the data. A ceiling price tends to promote negative skewness while a floor price tends to promote positive skewness. From a practical perspective, the presence of a positive skewness can help policy design, in that a positive price asymmetry means that a minimum price level can be established confidently (Sadiq *et al*. 2020). Similar findings were reported by Stigler (2011) and Sukati (2017). Besides, Mahalle *et al*. (2015); Sadiq *et al*. (2016a) examined the price trends of agricultural export commodities in their various studies.

The excess kurtosis coefficient showed all the market prices to be asymmetrically distributed and the distribution of their respective upper tails was thicker than the lower tails (positive skewness). The tails of distribution for Philippine and Thailand markets were thicker than the normal (kurtosis of >3) while that of the remaining two markets were not thicker than the normal. Excess kurtosis is a feature of markets that exhibit extreme prices values. Thus, the excess kurtosis exhibited by Philippine and Thailand markets may be associated to clustering volatility from 1966 to 2003 for each of the markets.

Table 1. Summary statistics of rubber prices for the selected markets

Markets	Mean	Min	Max	SD	CV	Skew-ness	Kurtosis
IC	941.22	177.34	3753.00	1019.00	1.082	1.956	2.256
IND	447.95	56.59	958.56	226.53	0.505	0.521	-0.598
PH	415.37	135.70	1741.30	321.44	0.773	2.273	5.392
TH	970.66	227.88	4066.70	809.55	0.834	1.900	3.619

Source: Computer printout, 2020

Lag selection criteria

A cursory examination of the VAR lag selection criteria, namely the Akaike information criterion (AIC), the Schwarz Bayesian criterion (SBIC), and the Hannan-Quinn criterion (HQC), suggested lag one as the length of lag for truncation, as indicated by the asterisks associated with their respective values (Table 2). As a result of including the reduced lag duration, the residual will be Gaussian white noise, with parsimonious interpretable output.

Table 2. Lag selection criteria

Lag(s)	AIC	BIC	HQC
1	49.724*	50.504*	50.019*
2	49.999	51.402	50.529
3	50.012	52.040	50.778
4	50.359	53.009	51.360

Source: Computer printout, 2020
Note: * denote lag length selected by a criterion

Testing for stationary

The results of the ADF unit root tests showed all the price series to be non-stationary at level as indicated by their respective tau-statistics which were not different from zero at 5% degree of freedom (Table 3). Further, the series were 1st differenced and subjected to the ADF test and all the variables became stationary as indicated by their respective tau-statistics which were within the plausible margin of 5% error gap. The KPSS unit root test, an alternate method rejected the null-hypothesis (stationary) for all the market prices at level as indicated by their respective absolute values which were greater than the t-critical at 5% probability level; but after first difference, with the exception of Ivory Coast market price, the null-hypothesis of all the remaining price series was accepted as their respective absolute values were lower than the t-critical values at 5% error gap. Given that the results of the former unit root test differed with the latter, thus there is need to verify the trend behaviors of the price series for parsimonious interpretable results.

Furthermore, an alternate unit root test method *viz*. ADF-GLS showed that at level all the prices series were non-stationary as evident from their respective absolute tau-statistic values which were lower than the t-critical values at 5% probability level. But after first difference, all the price series became stationary as indicated by their respective absolute tau-statistics which were higher than their t-critical values at 5% degree of freedom. This implied that at level, the residuals of all the prices had white noise but after first difference, all the price series residuals became Gaussian white noise. Given that the price series were all non-stationary at level and stationary at first difference, thus it can be inferred that they are integrated of the same order i.e. order 1[I(1)]. In addition, it reveals the tendency of these price series moving together in the long-run i.e. long-run association, thus the horizontal relationships between the market prices was estimated using Johansen co-integration test. As comparable varieties/grades of rubber across the different markets were selected, it can be assumed that variability in the prices is due to spatial effect and not varieties/grades differences. Hussain *et al*. (2010); Reddy (2012); Sekhar (2012); Beag and Singla (2014); Sundaramoorthy *et al*. (2014) established similar results for export commodities in their various studies.

Table 3. Unit root tests

Markets	Stage	ADF	KPSS	ADF-GLS
IC	Level	-0.343 (0.980)^{ns}	1.124^{ns}	-1.012^{ns}
	1st Δ	-4.209 (0.002)st	0.640st	-3.580st
IND	Level	-2.202 (0.207)^{ns}	0.230^{ns}	-1.912^{ns}
	1st Δ	-6.177 (2.8e-6)st	0.082st	-6.240st
PH	Level	-2.379 (0.147)^{ns}	0.190^{ns}	-2.468^{ns}
	1st Δ	-5.701 (6.03e-7)st	0.043st	-5.960st
TH	Level	-1.659 (0.44)^{ns}	0.186^{ns}	-2.48^{ns}
	1st Δ	5.606 (9.96e-7)st	0.043st	-6.102st

Source: Computer printout, 2020
Note: ADF-GLS and KPSS tau critical levels at 5% probability are -3.03 and 0.149 respectively.
ns, st, Δ means non-significant, stationary and first difference respectively. The values in parenthesis are probability values.

Extent of market integration (Bivariate co-integration)

The pair-wise co-integration test results showed existence of long-run price association between these market pairs *viz*. Ivory Coat and Indonesia; Ivory Coast and Philippines; and, Ivory Coast and Thailand as evident by their respective t-statistics for both the trace and Lmax tests which were outside the plausible margin of 5% at rank one (Table 4). In other word, it means that these market pairs had one co-integrating vectors. However, for market pairs viz. Indonesia and Philippines; Indonesia and Thailand; and, Philippines and Thailand, there is no long-run price communication between them as evident by their respective test statistics for both trace and Lmax tests which were not different from zero at rank zero. This implied that these market pairs had no co-integrating vector. Thus, it can be inferred that Ivory Coast market is more efficient in the international rubber market as it has a perfect flow of price information with its counterparts. In addition, it reveals the compliance of the Ivory Coast market with the WTO policies guiding marketing of rubber. The non-horizontal integration between the remaining markets in pair which are all located in Asia may be due to cold trade war. In the same vein, Beag and Singla (2014); Sundaramoorthy *et al*. (2014) conducted a similar co-integration test in their study which focused on market integration of export commodities in India.

Extent of market integration (multivariate co-integration)

Both the trace and Lmax tests showed the presence of two co-integrating vectors for the selected markets as indicated by their respective t-statistics which were outside the acceptable margin of 5% at rank 2 (Table 5). In other words, it implies that two markets are integrated out of the four selected markets in the rubber international market. Thus, it can be inferred that at least two co-integrating vectors exist besides two common stochastic trends among the four selected major rubber markets in the world. Hence, the evidence of two common stochastic trends means that two independent markets exist among the four selected markets. The presence of two common stochastic trends means the presence of pair-wise co-integration of prices, thus indicating that the law of one price (LOP) holds at moderate level in these international markets.

Table 4. Bivariate pair-wise co-integration

H_0	H_1	Eigen value	Trace test	P-value	Lmax test	P-value	Remark
IV-IN							
r = 0	r ≥1	0.441	29.804**	0.0001	29.682**	0.0000	**1 CE**
r≤ 1	r ≥2	0.0023	0.12182	0.7271	0.12182	0.7271	
IV-PH							
r= 0	r ≥1	0.65224	55.225**	0.0000	53.868	0.0000	**1 CE**
r≤ 1	r ≥2	0.02625	1.3569	0.2441	1.3569	0.2441	
IV-TH							
r= 0	r ≥1	0.61792	51.111**	0.0000	49.068	0.0000	**1 CE**
r ≤ 1	r ≥2	0.03926	2.0427	0.1529	2.0427	0.1529	
IN-PH							
r = 0	r ≥1	0.1232	10.646	0.2383	6.7096	0.5321	**NONE**
r ≤ 1	r ≥2	0.07428	3.9369	0.0472	3.9369	0.0472	
IN-TH							
r = 0	r ≥1	0.1018	8.1233	0.4596	5.4803	0.6837	**NONE**
r ≤ 1	r ≥2	0.05050	2.6430	0.1040	2.6430	0.1040	
PH-TH							
r = 0	r ≥1	0.1594	10.942	0.2187	8.8592	0.3050	**NONE**
r ≤ 1	r ≥2	0.0400	2.0824	0.1490	2.0824	0.1490	

Source: Computer printout, 2020
Note: **denotes rejection of the null hypothesis at 5 per cent level of significance
CE = Co-integration

Table 5. Multivariate horizontal-wise co-integration

H_0	H_1	Eigen value	Trace test	P-value	Lmax test	P-value
r = 0	r ≥1	0.65932	90.398**	0.0000	54.918**	0.0000
r ≤ 1	r ≥2	0.39346	35.480**	0.0445	25.499**	0.0317
r ≤ 2	r ≥3	0.13421	9.9808	0.4899	7.3500	0.6786
r ≤ 3	r =4	0.050277	2.6308	0.1048	2.6308	0.1048

Source: Computer printout, 2020
Note: **denotes rejection of the null hypothesis at 5 percent level of significance

Therefore, it can be inferred that the international rubber markets are moderately integrated in the long-run as two out of the four selected markets are co-integrated. Despite that the markets are geographically far apart and spatially isolated; their prices tend to move together in a moderate manner i.e. they are moderately connected in terms of rubber prices, thus indicating that the markets have long-run price linkage. The international rubber markets been moderately efficient may owe to trade policies and oligopolistic nature which characterized trading of this commodity. Since these market prices have long-run association, they are likely to establish a long-run equilibrium, thus the application of VECM model. Reddy (2012) found a similar result for export commodity in India. Besides, Sekhar (2012) reported that market commodity viz. edible oil and gram that did not face intra/inter-regional movement restrictions in India were well integrated. On the contrary, rice market due to maximum inter-state movement restrictions was poorly integrated. Also, Beag and Singla (2014); Sundaramoorthy *et al*. (2014); Praveen and Inbasekar (2015); Wani *et al*. (2015) established similar results for export commodities in their various studies.

Degree of market integration

The diagnostic test results of the VECM showed the model residuals for all the selected market prices to be normally distributed; had no problem of serial correlation and Arch effect as indicated by their respective t-statistics which were not different from zero at 10% degree of freedom. Thus, it can be inferred that the model fits the specified equation and the parameter estimates are reliable for future prediction.

The estimated VECM of the short-run dynamics of the co-integrated equation is shown in Table 6. The empirical evidence showed all the attractor coefficients of the selected markets at lag 1 to be negatively signed and only the market prices of Philippines and Thailand were significant. However, at lag 2, the attractor coefficients of all the selected markets turn-out to be positive and only market price of Philippines was significant. A positive attractor coefficient implies that the market price is above the equilibrium while negative attractor coefficient means that the market price is below the equilibrium. Sundaramoorthy *et al*. (2014) found one out of the three commodities in the market value chain of cotton in India to be integrated. Also, Mahallle *et al*. (2015) had similar findings in their study on wheat market integration in India.

At EC_{t-1}, with the exception of the market prices of Ivory Coast and Indonesia, the market prices of the remaining selected markets established a long-run equilibrium, thus indicating they are efficient. While at EC_{t-2}, only the market price of Philippines was efficient as it established a long-run equilibrium. Thus, a shock in these market prices that induces price deviations from the equilibrium will induced the traders to respond to the shock in a way that the prices will converge towards their equilibrium level. At EC_{t-1}, when the market prices of Ivory Coast, Indonesia and Thailand are too high; the market price of Philippines quickly adjusts toward the price levels of its counterpart markets at the same time when they are adjusting. Likewise, when the market prices of Ivory Coast, Indonesia and Philippines are too high; Thailand market price quickly converged towards the price levels of its counterparts at the same time when they are converging. However, at EC_{t-2}, if the market price of Philippines is too high, it quickly falls back towards the market price levels of its counterparts.

At EC_{t-1}, the speeds at which the market prices of Philippines and Thailand correct its long-run disequilibrium if there is any distortion from any of the short-run dynamics are -0.024 and -0.034 respectively. While at EC_{t-2}, the speed at which Philippines market re-established a long-run equilibrium in case of any internal or exogenous forces is 0.186. The appropriate time to be taken for market prices of Philippines and Thailand to re-establish long-run equilibrium at EC_{t-1} is less than a year. Also, at ECT_{t-2}, the time required for Philippines market price to re-establish equilibrium is less than a year. Furthermore, given that the estimated VECM did not yield short-run coefficient, it can be suggested that there is no delay in the short-run price transmission.

The granger causality displays the direction of price formation between two markets, as well as related spatial arbitrage, or the physical movement of commodities to compensate for price discrepancies (Table 7). A cursory review of the granger causality result showed existence of bidirectional causality between the market pair: Philippines and Thailand; and unidirectional causalities between the market pairs: Philippines and Ivory Coast; and, Thailand and Ivory Coast; as indicated by their respective t-statistics which were within the acceptable margin of 5% degree of freedom.

Table 6. Degree of market integration

Variable	∆IC	∆IND	∆PH	∆TH
Constant	−14.149(66.93)[0.21]^{NS}	25.06(41.01)[0.61]^{NS}	48.25(59.29)[0.81]^{NS}	5.839(130.4)[0.04]^{NS}
Time	−3.909(3.833)[1.02]^{NS}	0.545(2.349)[0.23]^{NS}	0.165(3.396)[0.04]^{NS}	8.481(7.473)[1.13]^{NS}
ECT_{t-1}	0.0113(0.009)[1.20]^{NS}	−0.0052(0.006)[0.90]^{NS}	−0.024(0.008)[2.91]**	−0.034(0.018)[1.90]*
ECT_{t-2}	0.0572(0.103)[0.551]^{NS}	0.021(0.063)[0.341]^{NS}	0.186(0.091)[2.02]**	0.140(0.202)[0.69]^{NS}
R^2	0.325	0.042	0.173	0.141
D-W stat	1.853	1.762	1.578	1.610
Autocor	0.278{ 0.598}^{NS}	0.712{ 0.399}^{NS}	2.328{ 0.127}^{NS}	1.995{ 0.158}^{NS}
Arch effect	9.428{ 0.241}^{NS}	4.245{ 0.236}^{NS}	1.562{ 0.135}^{NS}	1.410{ 0.275}^{NS}
Normality	11.93{ 0.154}^{NS}			

Source: Computer printout, 2020
Note: ** denotes rejection of the H_0 at 5% level of significance
NS: Non-significant
→ ←means forward and backward directions respectively

For the bidirectional causal related market, it implies that price change in the former market granger causes price formation in the latter market which inturn provides a feedback of price formation to the former market. In other words, it indicates the presence of perfect price formation synergy between the markets i.e. a feed-forward and feed-backward in price formation. While for the unidirectional causal related markets, it implies that the former markets in each pair granger causes price formation in the latter markets while price transmission in the latter markets have no effect on the market prices of the former. Thus, it can be inferred that there is presence of strong endogeneity and weak exogeneity effect for markets with bidirectional and unidirectional causal relationship respectively.

The market pairs *viz*. Ivory Coast and Indonesia; Indonesia and Philippines; and, Indonesia and Thailand had no causal relationship between the markets for each pair. This implies that neither the former market in each pair granger causes price formation in the latter market, nor the latter market granger causes price formation in the former market. This showed absence of perfect or partial synergy between the markets i.e. there is disconnection of price transmission between the markets in the pair. In addition, the presence of poor exogeneity revealed that the price formation in each of the market in the pair was determined by external factors i.e. the prices were determined outside the system. Generally, it can be concluded that there are perfect and partial long-run price transmissions for the bidirectional and uni-directional causal related markets, respectively, while the long-run price association was poor for markets with no causal price relationship. Therefore, it can be inferred that the market price of Philippines had dominant role in the international market of rubber. Mahalle *et al*. (2015) found various price communications in their study.

Effect of local shock on the prices of the selected markets

If unit root or co-integration exists, the estimation of the impulse response function (IRF) at long horizon is inconsistent when calculated from the unrestricted VAR. As a result, the impulse's stable response function was recovered from the error correction model. While IRFs from a stationary VAR eventually die out, IRFs from a co-integrating VECM don't always do so. Because each variable in a stationary VAR has a time-invariant mean and a limited, time-invariant variance, the shock's effect on any of these variables must fade away before the variable may return to its mean value. The 1(1) variables modeled in a cointegrating VECM, on the other hand, are not mean reversal, and the unit module in the companion matrix indicates that the effects of some shocks will not fade away with time.

The unexpected shock that is local to the market prices of Ivory Coast will have a permanent effect on its own market and a transitory effect on the market prices of all the remaining markets. An orthogonized shocks to the average market prices of Indonesia and Philippines will have a transitory effect on themselves, each other and Thailand market; and a permanent effect on the market prices of Ivory Coast. However, an unexpected price shock that is local to the average market prices of Thailand will have a transitory effect on its own market prices and that of Indonesia; and a permanent effect on the average market prices of Ivory Coast and Philippines. Thus, a transitory shock effect on a market price tends to dies out over time while a permanent shock effect tends not to die out over time. A shock that emanates from Thailand market is more transmitted to all the selected rubber markets while a shock that emanates from any of the selected market is relatively less transmitted to the Thailand market. Thus, it can be inferred that Thailand market has dominance in the price determination of all the selected international rubber markets while all the latter markets viz. Ivory Coast, Indonesia and Philippines markets are relatively market followers and do not play a significant role in the international rubber markets. However, it is worth to distinguish that Indonesia and Philippines markets are passive followers while Ivory Coast market is an active follower in the international rubber market. Beag and Singla (2014); Sundaramoorthy *et al*. (2015) observed different price shocks and responses across the market value chain of cotton in India.

Price forecast of the selected markets

The one-step-ahead forecast was used to test the validity of the best fit VECM's predictive power, as well as how closely they could follow the direction of the real observations (Table 7).

Table 7. One step ahead forecast of prices

Period	Ivory Coast		Indonesia		Philippines		Thailand	
	Actual	**Forecast**	**Actual**	**Forecast**	**Actual**	**Forecast**	**Actual**	**Forecast**
2013	3366.931	3469.267	781.9341	829.09	950.6151	1037.49	2432.793	2539.28
2014	3505.758	3679.951	621.8178	751.11	594.0282	894.19	1660.417	2283.76
2015	3603.402	3701.83	503.8309	617.6	446.3242	614.14	1289.722	1697.26
2016	3682.405	3725.207	479.0985	509.83	470.1795	472.02	1382.861	1402.29
2017	3752.972	3824.012	549.6652	482.5	578.9258	494.97	1644.382	1482.03

Source: Authors' computation, 2020

Table 8. Validation of models

Market	R^2	MAPE	RMSPE	RMAPE (%)	RMSE	Theil's U
IC	0.978424	-77.2926	2.637226	-2.15111	96.86094	0.88323
IND	0.929631	-41.3255	12.55031	-7.51371	83.80389	0.894916
PH	0.873075	-77.1725	45.39038	-14.8038	158.3106	0.893447
TH	0.894418	-177.592	75.81835	-12.1344	158.3106	0.852356

Source: Authors computation, 2018

Table 9. Out of sample price forecast of the selected markets ($ per ton)

Year	Ivory Coast			Indonesia		
	Forecast	**LCL**	**UCL**	**Forecast**	**LCL**	**UCL**
2018	3938.42	3595.20	4281.64	545.45	335.12	755.78
2019	4136.52	3580.08	4692.96	539.68	251.05	828.32
2020	4344.75	3588.36	5101.14	532.29	187.45	877.13
2021	4561.91	3614.72	5509.10	523.40	133.14	913.65
2022	4787.26	3657.85	5916.68	513.15	83.88	942.42
2023	5020.28	3717.09	6323.47	501.67	37.61	965.73
2024	5260.56	3791.81	6729.30	489.05	6.78	984.88
2025	5507.79	3881.38	7134.20	475.37	49.96	1000.70
2026	5761.74	3985.12	7538.36	460.68	92.34	1013.72
2027	6022.22	4102.36	7942.09	445.04	134.21	1024.31
Year	**Philippines**			**Thailand**		
	Forecast	**LCL**	**UCL**	**Forecast**	**LCL**	**UCL**
2018	589.91	285.85	893.96	1695.83	1026.80	2364.87
2019	600.94	217.49	984.38	1741.12	900.01	2582.23
2020	609.47	187.09	1031.86	1779.86	857.19	2702.52
2021	615.38	172.94	1057.82	1812.95	849.73	2776.16
2022	618.98	166.01	1071.97	1841.38	858.18	2824.58
2023	620.65	161.93	1079.36	1865.99	873.31	2858.66
2024	620.66	158.54	1082.79	1887.43	890.49	2884.36
2025	619.27	154.75	1083.80	1906.21	907.39	2905.03
2026	616.67	150.07	1083.27	1922.73	922.89	2922.58
2027	612.98	144.28	1081.68	1937.31	936.54	2938.08

Source: Computer printout, 2020

Table 10. Price volatility of rubber in the selected markets

Items	**Ivory Coast**	**Indonesia**	**Philippines**	**Thailand**
		Mean equation		
Arch Effect	125.51{5.56e-28}***	12.22{0.0067}***	9.16{ 0.010}**	26.2{ 1.95e-6}***
		Variance equation		
Intercept	223.86(59.47)[3.76]***	-	−39.85(13.92)[2.86]***	48.90(37.05)[1.32]NS
Ivory Coast	-	0.037(0.025)[1.48]NS	−0.035(0.007)[4.44]***	0.053(0.010)[5.13]***
Indonesia	0.392(0.214)[1.82]*		0.151(0.116)[1.30]NS	0.212(0.156)[1.35]NS
Philippines	0.916(0.742)[1.23]NS	0.396(0.803)[0.49]NS	-	2.143(0.076)[28.1]***
Thailand	−0.240(0.257)[0.93]NS	0.125(0.333)[0.37]NS	0.411(0.027)[15.05]***	-
Alpha (1)	0.928 (0.251)[3.69]***	0.493(0.293)[1.67]*	0.641(0.394)[1.62]NS	0.745(0.816)[0.912]NS
Alpha (2)	-	1.0e-12(0.969)[0.00]NS	-	-
Beta (1)	1.0e-12(0.044)[0.00]NS	0.454(0.596)[0.76]NS	0.358(0.242)[1.47]NS	0.221(0.528)[0.41]NS
α + β	0.928	0.947	0.999	0.966
GARCH fit	1,1	2,1	1,1	1,1
Normality	186.9{2.58e-41}***	5.76{ 0.056}*	5.22{ 0.073}*	17.8{0.0001}***
Autocorrelation	0.286{0.59}NS	1.277{0.53}NS	1.821{0.61}NS	2.59{0.63}NS

Source: Computer printout, 2020 Note: *** ** * implies significance at 1%, 5% and 10% respectively
NS: Non-significant; and values in ( ); [ ] and {} are standard errors, t-statistics and probability values.

Furthermore, the VECM was shown to be accurate for prediction, as evidenced by the inequality coefficient (U) of Theil and the relative mean absolute prediction error (RMAPE), which are both within 1% and 5%, respectively (Table 8). Because the predictive error associated with the estimated equation is negligible and low in monitoring the actual data, the VECM can be utilized for ex-ante projection with high projected validity and consistency (ex-post prediction).

Figure 1-4 and Table 9 exhibit the one-step-ahead-out of the sample projection of producer price of rubber for all selected markets for the period 2018 to 2027. It was observed that the market prices of Ivory Coast and Thailand will witnessed a gentle rise throughout the forecasted period while the market prices of Philippines will be marked by a gentle increase from 2018 to 2023; maintained status quo i.e. stagnant in the immediate succeeding year i.e. 2024; and, afterward slightly recess till the end of the forecasted period. On the other hand, the market prices of Indonesia will witnessed a slight plummeting price trend till the end of the forecasted period. Thus, product quality will make the rubber market prices of Ivory Coast, Thailand and Philippines to be remunerative while quality and oligopolistic activities of the middlemen will affects the market prices of Indonesia rubber in the international market. Thus, there is need for the policymakers in Indonesia to checkmate the activities of the oligopolistic middlemen and should enhance their rubber product quality for competitive market.

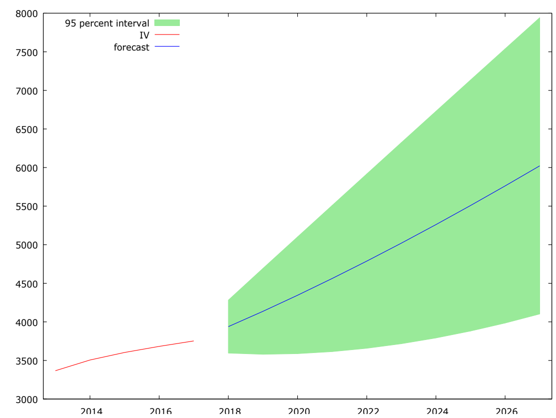

Figure 1. Rubber price forecast of Ivory coast market

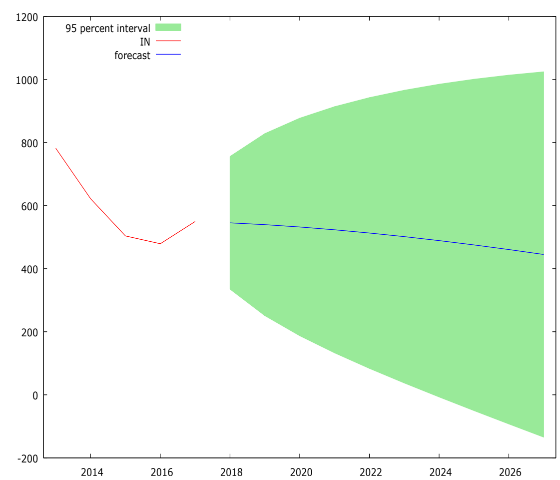

Figure 2. Rubber price forecast of Indonesia market

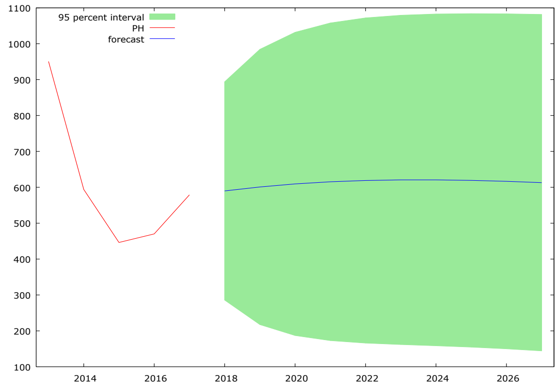

Figure 3. Rubber price forecast of Philippines market

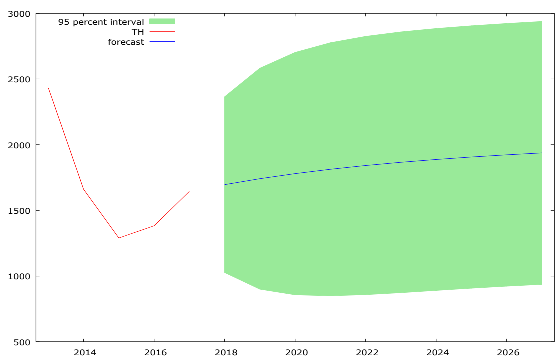

Figure 4. Rubber price forecast of Thailand market

Extent of price volatility

The results of the pre-condition for volatility test showed evidence of clustering and Arch effects in all the residuals of the selected market prices. For market prices of Ivory Coast, Philippines and Thailand, GARCH (1,1) was found to be the best fit for the specified equation while for Indonesia market prices, GARCH (2,1) was found to be the best fit for the specified equation (Table 10). Lama *et al*. (2015) in their study on price volatility modeling and forecasting of international edible oils established a similar finding.

The diagnostic test showed that the residuals of each of the estimated model had no problem of autocorrelation as evident from their respective Q-statistics which were not different from zero at 10% degree of freedom. However, the estimated GARCH (1,1) models residuals failed the test of normality as indicated by the significant of all the t-statistics at 10% degree of freedom. A problem of non-normality of the residual is not considered a serious issue as data in their natural forms in most cases are not normally skewed.

A cursory review of the GARCH estimates showed the (α + β) coefficients for each of the selected markets to be close to 'one', indicating the presence of persistence volatility in the rubber prices at international market. Thus, none of the market prices had their sum coefficients of (α + β) to exceed one, thus indicating the absence of 'explosive' pattern in the prices of selected markets in the rubber international market. Therefore, it can be inferred that rubber marketing is useful in the international market. Sendhil *et al*. (2013) established similar results in their study on agricultural commodity future markets.

Furthermore, it was observed that only two markets *viz*. Ivory Coast and Indonesia had their current rubber prices been affected by speculative information about previous price arbitrage of rubber as evident by the significant of their respective Arch (α) estimated coefficients at 10% acceptable margin. It was observed that previous market prices had no effect on the current prices of all the selected markets as indicated by the non-significant of their respective GARCH (β) estimated coefficients. Furthermore, it was observed that in Ivory Coast market only the market price of Indonesia caused volatility in its current market price while in Indonesia market none of the selected market prices triggered its volatility. Also, the volatility in the current market prices of Philippines was affected by market prices of Thailand and Ivory Coast while the international shock that affected market prices of Thailand were market prices of Ivory Coast and Philippines. Volatility in the current market prices of Indonesia was not affected by external shock. Therefore, it can be inferred that volatility in the current market prices of Ivory Coast was affected by both family and external shocks; while only international shock triggered volatility in the current market prices of Philippines and Thailand. However, volatility in the current market prices of Indonesia was only due to internal shock.

CONCLUSION AND RECOMMENDATIONS

Based on the findings, it can be inferred that the law of one price holds among these markets despite been spatially separated. However, the pair-wise cointegration showed market prices of Ivory Coast to have effective linkage with all the other selected markets. Furthermore, only the market prices of Philippines and Thailand were stable in the long-run as they established long-run equilibrium and are capable of absorbing any shock that originates from any of the short-run dynamics. The market prices of Philippines and Thailand were determined within the system while that of Ivory Coast and Indonesia were determined by external factors. Empirical evidences showed Thailand market to have a dominant effect on price determination in the rubber market as all the remaining markets were relative market followers with no significant influence in the international rubber markets. It was established that rubber marketing is useful in the international market as all the selected market prices witnessed persistent volatility. Lastly, poor quality and exploitative activities of the oligopolistic middlemen will affect the prospect of the market prices of Indonesia. Thus, the study suggests that the marketing network of rubber should be enhanced in order to ensure efficient spatial linkages. This will help in boosting inter-market competition and control of massive marketing margin which affects the stability of the long-run equilibrium of Ivory Coast and Indonesia markets.

AUTHOR'S CONTRIBUTION

M. S. Sadiq: 40%
I. P. Singh: 30%
M. M. Ahmad: 30%

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