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Time-Varying Structure of the Optimal Hedge Ratio for Emerging Markets

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Abstract

Emerging markets are more exposed to risk than developed markets. Therefore, they require risk management using futures market instruments. This study aims to determine the hedging effectiveness of the spot index market risks in the stock index futures market in Brazil, Russia, India, South Africa, and Turkey. Measuring the hedging effectiveness level of futures markets is vital for these countries because investors must remain in the stock markets for the sustainability of the financial markets and economies. Weekly closing data for the period from January 2009 to October 2021 were analyzed via a dynamic method referred to as flexible least squares (FLS). Although the FLS results show that futures transactions provide high hedging effectiveness for all countries within the scope of this study, country-specific conditions may reduce the hedging effectiveness.

Keywords: financial markets; asset markets; spot and future market; optimal hedging ratio.

JEL classification: G10; G11; G14; G15; C58.

1. INTRODUCTION

Most developing countries attach importance to fund accumulation in financial markets toward sustainable economic development and strive to increase the number of institutional and individual investors in all markets, especially stock markets. In this context, individual investors, as stock market participants, are required to remain permanently in this market for a long time. Sustainability in stock markets can only be possible through the protection of (against) investors' rights (risks) when trading in these markets. The proper implementation of investor protection principles contributes to the participation (permanence) of new (existing) investors in these markets. Investors' risk in the stock market entails fluctuations in the stock price and/or stock index. To manage such spot market risks, the existence of a derivative financial instrument suitable for the spot market is required. These risks that ensue in the spot market can be managed through appropriate futures market transactions, whereby investors who can manage the spot market risk can contribute to the sustainability of stock

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and financial markets. To determine the level of success of a futures market in managing the risks in the spot market, it is necessary to investigate the relations between these two markets and determine the degree of protection of the risks in the spot market by futures market transactions. This constitutes a rationale for this study.

The relationship between spot and futures markets is important in today's academic and financial world. Futures are used for hedging, speculation, and arbitrage. Sutcliffe (1993) explains the effects of using derivatives as follows:

a) Risks arising from adverse price fluctuations in the spot market can be reduced
b) Risks arising from price movements in the spot market can be reduced
c) Profit can be made from price changes
d) Portfolio options that provide maximum return at minimum risk level can be created

While many academic studies have established that futures prices affect spot prices, some studies have reported the contrary – spot prices affect futures prices (Hutcheson, 2003, p. 2). The most evident reasons why futures prices affect spot prices are the low transaction costs, the leverage effect, and the fact that traders are experts. Other reasons include numerous participants ranging from hedge funds to corporate hedgers and a high level of price transparency (Rosenberg & Traub, 2009, p. 1). While Güzel (2021) found bidirectional causality in the USD–TRY foreign exchange market, it was determined that the causality from forward to spot rates was stronger than that from spot to forward rates. This shows that futures markets continue to play a leading role in determining prices in spot markets. However, mostly there are two way interaction between both markets depend on the liquidity (Ersoy & Çıtak, 2015).

In recent years, digitalization and the increase in the financial literacy level of individuals worldwide have contributed to the use of derivative products to hedge financial risks (Hsiao & Tsai, 2018; Antova & Tahar, 2020; Rasool *et al.*, 2021). Both national and global risk factors in the markets require the management of personal risks of individuals and the hedging of risks arising from commercial business transactions.

Theories developed on hedging start with "Traditional Hedging Theory" and "Portfolio Hedging". The traditional hedging theory states that investors can protect themselves by taking a futures position with an equal nominal value, albeit with the opposite sign (Kalayci & Zeynel, 2009, p. 44). According to Traditional theory, zero change in the basis, which is the difference between futures and spot prices, is defined as "perfect hedging". In the traditional theory, it is assumed that spot and forward prices move together and the profit or loss in the futures market can be compensated for the loss or profit in the spot market. Another theory in terms of hedging is the portfolio hedging theory. In this theory, portfolios of spot and futures markets are not seen as interchangeable tools. Instead, it is decided how much of this portfolio is hedged. To achieve the hedging more effectively, the relationship between spot and futures prices, measured by beta – which is used as the optimal hedge ratio (OHR) – should be close to one.

The value of a portfolio against one unit change in the price of a futures contract used for hedging is expressed as the "OHR" (Kalayci & Zeynel, 2009, p. 46). Actuallly, OHR is based on the Ederington's hedging effectiveness measure (EME) which arise from Johnson (1960) and Stein (1961) who started portfolio theory to hedging. Ederington (1979) defines hedging effectiveness as the decrease in the return variance of the hedged portfolio compared to the return variance of the unhedged portfolio. Two models are used to evaluate the OHR, they are the conventional constant OLS and multivariate GARCH models. A constant hedge ratio is found using OLS, and a time varying OHR is calculated using diagonal VECH, a multivariate GARCH model (Buyukkara *et al.*, 2022).

As Fabozzi and Fabozzi (2022) summarized;

> *An optimal hedge ratio based on variance minimization is the slope coefficient estimated from an ordinary least squares (OLS) regression of the returns of the portfolio to be hedged on the returns of the stock index futures contract. The estimated slope coefficient is referred to as beta. The optimal hedge ratio can be further refined by adjusting for the beta estimated from an OLS regression of the return on the underlying stock index on the return on the stock index futures.*

For futures to be used as hedging instruments, there must be a strong relationship between the futures and the underlying spot asset that needs to be hedged. While the positive relationship between the spot and futures markets increases the hedging effect of futures use, the negative relationship between the two markets reduces the hedging effect of the futures market. The hedging effect with futures transactions may change with the effect of volatility and the special conditions in the markets (Buyukkara *et al.*, 2022). Additionally, mismatches between the spot and futures markets' trading hours may also lead to a decrease in risk hedging effectiveness. An important point in determining the OHR is whether the relationship between the two variables is linear—if so, it becomes difficult to determine the true hedging effect (Özaydın, 2018) because the relationship between time series changes with time. Therefore, it is necessary to measure the relationship between spot and futures markets using non-linear methods.

We have selected markets data of Brazil, Russia, India, Turkey (Türkiye) and South Africa Republic to see hedging effectiveness of the futures markets. Because, developing countries are more open to the different types of risk than developed countries. And, financial market volatility in these countries higher. Therefore, it is so important to see the relationship between spot markets and futures markets in these countries. To see the hedging effectiveness of the futures markets in these countries will help the investors, portfolio managers to manage their assets more successful.

And, since the beginning of 2020, the coronavirus disease 2019 (COVID-19) pandemic has affected all countries negatively. However, some sectors were positively affected by the pandemic during this period. These developments have also revealed the need for a significant number of investors to hedge the risks taken in the spot market more effectively with the futures market. Therefore, the dynamic relationship between spot and futures markets needs to be examined. This study aims to investigate the nonlinear relationship between spot and futures markets in Brazil, Russia, India, South Africa, and Turkey – some of the significant emerging markets worldwide. The remainder of this paper is organized as follows. Sections 2, 3, 4, 5 and 6 elucidate the empirical literature, data and methodology, findings, discussion, and policy implications, respectively.

2. LITERATURE REVIEW

Many academic studies explore the hedging effectiveness of futures transactions with different data structures and methods for different periods. Kaur and Gupta (2018) investigated hedging effectiveness using the three main benchmark indices – NIFTY50, NIFTYIT, and BANKNIFTY – in the National Stock Exchange (NSE) of India. The study with daily data covering the period 2000–2017 showed that the ordinary least squares (OLS) method produced more appropriate results. Kalayci and Zeynel (2009) determined that futures transactions were effective in hedging spot market risks by using daily futures index data from February 2005 to December 2007. Gök (2016) used the OLS, error correction model (ECM), generalized autoregressive conditional heteroskedasticity (GARCH) model, ECM-GARCH model, diagonal VECH-GARCH, and diagonal BEKK-GARCH models from multivariate GARCH models in his study. The author measured the hedging effectiveness of stock index futures transactions by using the end-of-day data of the daily BIST 30 index spot and futures markets for the period from November 1, 2005, to October 30, 2015. The study results showed that the ECM-GARCH model in daily hedging provided better protection than the multivariate GARCH models in different periods.

Özaydın (2018) used weekly data from January 9, 2009, to December 31, 2017, and determined that the hedge rate determined by the ECM produced reliable results. Büberkökü (2019) attempted to determine the hedge efficiency of futures transactions using daily BIST 30 and VIOP 30 data for the period from February 2005 to August 2013. The author found that the OHR presented by the DBEKK model provided more effective results. In the same data period, Çelik (2014) determined that the hedge ratios obtained by dynamic methods were more reliable and consistent. Further, Buyukkara *et al.* (2022) analyzed the daily data of BIST 30 spot index and VIOP 30 futures index with OLS and GARCH models and attempted to determine the OHR. They concluded that the futures market is an effective hedging mechanism for investors with stock portfolios. Gupta and Singh (2009) also discussed the hedging effectiveness of NIFTY, BANKNIFTY, CNXIT, and 84 most liquid stock futures traded on the NSE of India during 2003–2006. They determined that the OLS model provided more effective hedging during the study period. Moreover, Anjana Raju and Velip (2018) used two constant and two time-varying models to examine the hedging effectiveness of the NIFTYIT index stocks in the period 2011–2017. The study findings indicated that the vector error correction model (VECM) had higher hedging effectiveness than other constant and two time-varying models. Through the VECM, the authors determined that a high hedge ratio was achieved for all stocks included in the IT index.

Lakshina (2017) investigated the level of hedging effectiveness for the period 2002–2016 using data from 17 stocks and stock futures. The author tested multivariate GARCH models – general orthogonalized GARCH, copula-GARCH, asymmetric dynamic conditional correlations (ADCC), and stochastic volatility (MSV) models. According to the analysis results, the ADCC and MSV models were recommended to create hedging strategies according to maximum risk in the Russian stock market. Singh (2017) investigated the hedging effectiveness by using the daily closing data of three main indexes in NSE-India for the period 2011–2015. The OLS, GARCH, EGARCH, TARCH, and VAR models, as well as the VECM, were tested in his study. The study findings showed that while the EGARCH model was lowest for NIFTY and BANKNIFTY, the OLS model showed the lowest OHR as compared to that estimated through other models for NIFTYIT.

Tarchella and Dhaoui (2021) investigates the hedging performance of alternative assets including some financial assets and commodities futures for the Chinese stock market in a multi-scale setting before and during the COVID-19 pandemic time. Interestingly they found out that Bitcoin provides the best hedge to the Shanghai stock market in short time. However, the authors revealed that commodities futures are good hedge assets in the long time. Hamma *et al.* (2021) examines the hedging of conventional and Islamic stock market risks using diverse financial assets. They found that the hedge ratios vary and depend on the inclusion of hedging assets, portfolio composition and model used. Especially, The EURO STOXX 50 Volatility index

(VISTOXX) is the best asset to hedge Islamic and conventional stock portfolios. Zainudin and Mohamad (2021) examines the cross hedging effectiveness between UK FTSE100 and world stock index futures from developed and emerging markets. Authors used daily data from 2002 to 2019 by OLS, VECM and Maximal Overlap Discrete Wavelet Transform (MODWT). They found that the US E-Mini DJIA$5 futures contract is the best cross hedging instrument for the UK FTSE100, followed by the Australia S&P/ASX 200. Urtubia *et al.* (2021) investigated the alternative possibilities for hedging spot positions on the FTSE LATIBEX Index in Brazil. Because, there isn't a futures market on the index. Authors revealed that the futures contracts on the Brazilian index BOVESPA provide the most effective cross-hedge for LATIBEX.

Although the literature is extensively vast so far, to the best of our knowledge, limited number of studies have evaluated to investigate hedging effectiveness of stock futures indices, notably, the studies covering certain countries such as South Africa, Russia, and Brazil. We think that this is an element of novelty in terms of economic literature. Besides, we use of dynamic method instead of static methods the optimal hedging efficiency.

3. DATA AND METHODOLOGY

3.1 Data

According to the World Futures Exchange (WFE) 2021 trading volume data, the most liquid stock futures market of the world is B3-Brasil Bolsa Balcão (Brazil) (World Federation of Exchanges, 2021, p. 41). Moscow Exchange (Russia) is the 5th, Borsa Istanbul (Türkiye) 10th, National Stock Exchange of India (India) 11th and Johannesburg Stock Exchange (South Africa Republic) is 23rd in the list.

In this study, we used the weekly closing data of stock market spot and futures indices of selected developing countries (Brazil, Russia, India, South Africa, and Turkey) for the period from January 2009 to October 2021 (Table no. 1).

The data used are from different contracts with different maturities; belongs to the stock index futures contract with the shortest maturity. Thus, these contracts reflect the highest trading volume for each stock index. According to Buyukkara *et al.* (2022), volatility of the markets causes negative impact on the hedge effectiveness. The weekly data has lower volatility than daily data. Therefore, using weekly data can cause more powerful hedging effectiveness.

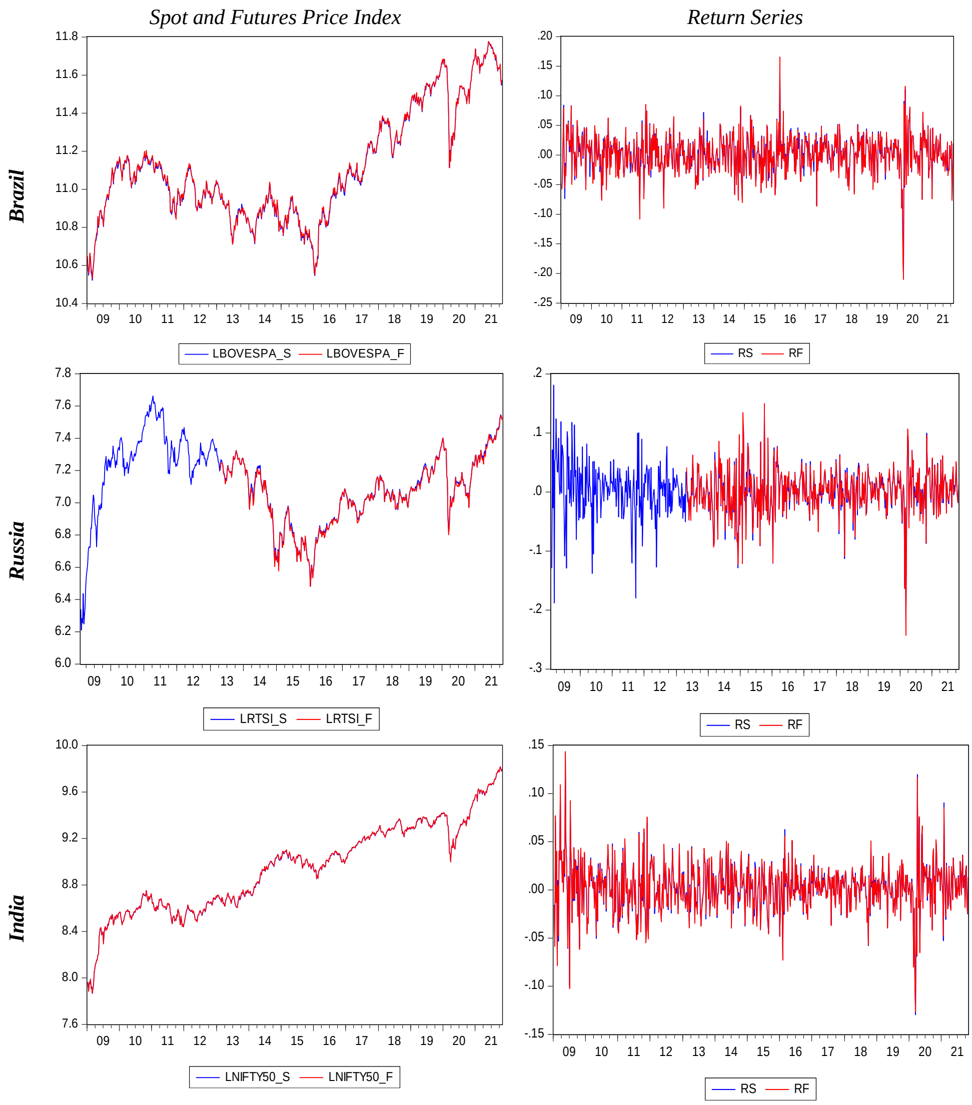
Data are based on the end-of-day closing (settlement) prices for the spot (futures) market. Additionally, we performed logarithmic transformations of all spot and futures price series and calculated the difference in logarithmic prices for the return series.

Table no. 1 – Data of the study

	Spot Index	*Futures Index*
Brazil	BOVESPA_S	BOVESPA_F
Russia	RTSI_S	RTSI_F
India	NIFTY50_S	NIFTY50_F
South Africa	SA40_S	SA40_F
Turkey	BIST30_S	VIOP 30

Sources: conducted by authors

Although many academic studies analyze China among developing countries, it is excluded from the scope of this study. As of 2021, China is the second-largest economy in the world in terms of gross domestic product (GDP). Although China's GDP per capita is low, its economic size shows that it has effects similar to those of developed markets (Özen & Tetik, 2019). Figure no. 1 shows the change in logarithmic spot and futures price index ($spot_t$ and $futures_t$) and returns series (rs_t and rf_t) over time in all the selected countries.



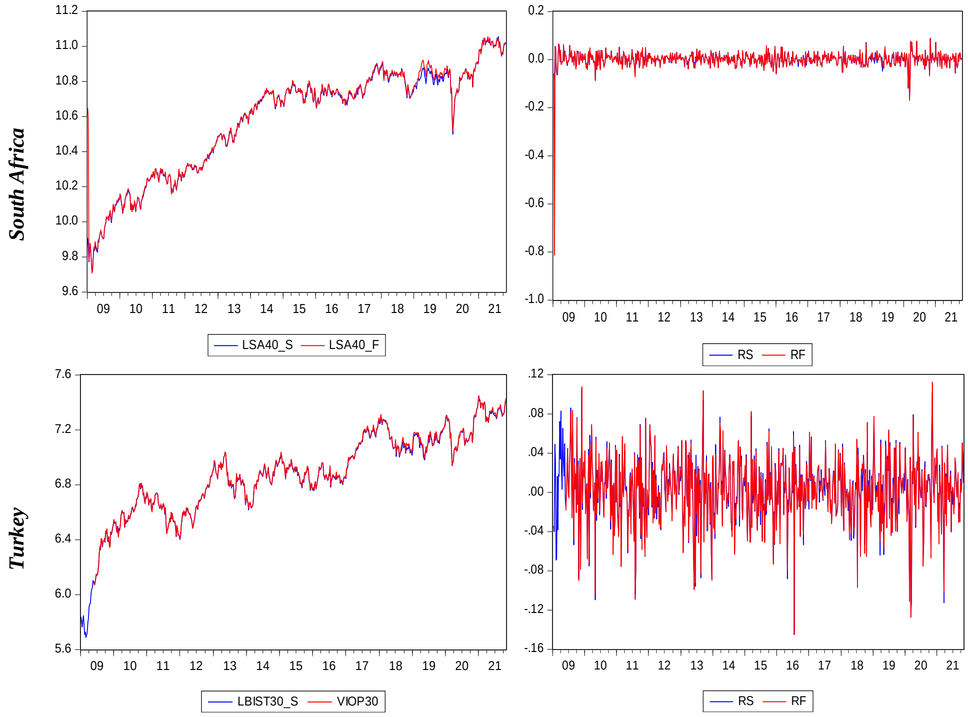


Figure no. 1 – Graphs of indexes

Sources: conducted by authors

In this study, we estimated one-week OHRs. We obtained the data from investing.com.

3.2 Methodology

In this study, a model similar to that of Brooks (2008) was used to estimate the time-varying structure of the OHR.

$$rs_t = \alpha + \beta rf_t + \varepsilon_t \quad (1)$$

In Equation 1, rs_t represents the logarithmic return of the spot prices, rf_t represents the logarithmic return of futures, β represents the OHR, and α is the intercept term. The FLS approach developed by Kalaba and Tesfatsion (1989) was used to estimate the time-varying structure of the OHR obtained from the model in Equation 1. Owing to the problems caused by the financial data used in the estimation results, Equation 1 was estimated using the generalized flexible least squares (FGLS) and flexible error correction model (FECM) methods. In this context, the OHRs obtained via the FGLS and FECM methods – which change with time—constitute the original part of this study.

The FLS procedure is a multicriteria estimation approach to discover the particular coefficient vector obtained at each time *t*, considering all times *T*. Similar to OLS, FLS minimizes the objective function as follows:

$$O(\beta) = \sum_{t=1}^{T} (rs_t - (\alpha + \beta rf_t))^2 \quad (2)$$

The main advantage of the FLS procedure over OLS is that it does not require any distribution assumptions. This solves the time-varying linear regression problem with minimal assumptions. For the FLS algorithm procedure, we assume that rs_t is a time series that conforms to the time-varying coefficient model:

$$rs_t = \alpha_t + \beta_t rf_t + \varepsilon_t \quad (3)$$

In Equation 3, all parameters (α, β) are time-varying structures, and β_t represents the time-varying OHR estimation vector. The OLS method is based on the assumption that there is no dynamically varying linear dependence between $rs_t - \beta_t rf_t \neq 0$, that is, rs_t and rf_t. However, the FLS method is based on the assumption that the $\beta_{t+1} - \beta_t \neq 0$ coefficients change over time. Thus, the FLS approach estimates the coefficient of a particular period *t* differently from the other periods. In this case, an estimated parameter vector $\beta_t = (\beta_{1t}, \beta_{2t}, ..., \beta_{kt})$ was obtained for each period. To estimate these parameters, the FLS approach uses a different version of the OLS objective function of the equation. In this case, the objective function to be minimized is as follows:

$$O(\beta;\mu) = \sum_{t=1}^{T} (rs_t - (\alpha_t + \beta_t rf_t))^2 + \mu \sum_{t=1}^{T} (\beta_{t+1} - \beta_t)^2 \quad (4)$$

If the $\beta_{t+1} - \beta_t = 0$ constraint is valid – there is no change between the estimated coefficients – the FLS and OLS methods yield the same results. However, if this restriction is invalid, the two methods may yield different results (Yıldırım, 2016). Kalaba and Tesfatsion (1989) presented an innovative algorithm for the minimization procedure in Equation 4 (Can, 2021) – for detailed information on estimation procedures, refer to Kalaba and Tesfatsion (1989). Notably, FLS is more flexible as it allows temporal variation in the coefficients. Moreover, OLS is a special case of FLS, wherein a constraint that fixes potentially time-varying coefficients to constant values is applied (Soybilgen & Eroğlu, 2019).

A criticism that may be encountered while estimating the OHR with OLS (FLS) is that the OLS estimation does not consider the cointegration between the series. If there is such cointegration, the error correction term should be included in the OLS equation to eliminate the specification bias (Lien *et al.*, 2016). Thus, the OLS equation between the logarithmic price series in Equation 1 is estimated, similar to the process in Lien and Shrestha (2005)'s study. Subsequently, the unit root test was performed on the error terms, and the following FECM procedure was created:

$$O(\beta;\mu)=\sum_{t=1}^{T}(rs_t-(\alpha_t+\beta_t rf_t+\delta_t\varepsilon_{t-1}))^2+\mu\sum_{t=1}^{T}(\beta_{t+1}-\beta_t)^2(\delta_{t+1}-\delta_t)^2 \quad (5)$$

Another criticism of the estimation of OHR with OLS(FLS) is the assumption that the residuals obtained from the OLS estimation has a homoscedastic and non-autocorrelated. However, it is concluded that the residuals in many time series has heteroscedastic and is autocorrelated. When these assumptions are violated, the OLS estimators remain linear and unbiased, albeit inefficient. In this case, the generalized least squares (GLS) method can produce the best linear unbiased estimators. The GLS method is based on the assumption that the heteroscedasticity and serial correlation structure of the error term is known. In this case, all variables in Equation 1 are transformed using this information (rs_t^*, rf_t^*). The OLS process runs with transformed variables. The GFLS approach developed to estimate the GLS parameters ($\alpha_t^*, \beta_t^*, \mu^*$) is similar to the FLS objective function. Nevertheless, all the variables and parameters in Equation 1 were transformed.

$$O(\beta^*;\mu^*)=\sum_{t=1}^{T}(rs_t^*-(\alpha_t^*+\beta_t^* rf_t^*))^2+\mu^*\sum_{t=1}^{T}(\beta_{t+1}^*-\beta_t^*)^2 \quad ()$$

The autoregressive conditional heteroscedasticity models proposed initially by Engle (1982) and later by Bollerslev (1986) were not used in this study when the variance of the error terms was not constant. Along with the finding of Holmes (1996) that OLS outperforms advanced models, we focused on estimation techniques based on OLS because of the simple and understandable nature of the OLS model.

4. FINDINGS

Table no. 2 shows the descriptive statistics of the spot and futures return series for all stock markets during the sampling period.

Table no. 2 – Descriptive statistics

	Brazil		Russia		India		South Africa		Turkey	
	rs_t	rf_t	rs_t	rf_t	rs_t	rf_t	rs_t	rf_t	rs_t	rf_t
Mean	0.0014	0.0014	0.0007	0.0007	0.0027	0.0027	0.0017	0.0006	0.002	0.0021
Median	0.0031	0.003	0.0014	0.0015	0.0034	0.0038	0.0026	0.0022	0.0039	0.0043
Maximum	0.1656	0.165	0.1469	0.1495	0.1436	0.1432	0.0887	0.0873	0.1038	0.1125
Minimum	-0.2092	-0.2102	-0.2378	-0.2429	-0.1296	-0.1263	-0.1693	-0.8127	-0.145	-0.1447
Std. Dev.	0.0323	0.0328	0.0385	0.0393	0.0256	0.0259	0.0244	0.0399	0.0338	0.0344
Skewness	-0.4948	-0.5103	-0.7172	-0.687	0.041	0.0471	-0.6742	-12.746	-0.5509	-0.483
Kurtosis	7.4679	7.3029	7.3475	7.4766	6.8337	6.7303	7.7696	258.554	4.3421	4.2967
Jarque–Bera	583.735	545.123	388.6056	406.580	409.873	388.127	684.805	1838579	81.5354	70.7
Probability	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations	669	669	445	445	669	669	669	669	649	649

Sources: conducted by authors

While the skewness values are at the level of the normal distribution values in the weekly return series within the sample periods, the kurtosis values are not at the same level. Moreover, when the Jarque-Bera test results are examined, weekly returns are not normally distributed. Before estimating the model, we investigated the stationarity properties of the spot and futures return series. We performed standard unit root tests to examine the stochastic properties of the variables in question. The ADF (Dickey & Fuller, 1981), PP (Phillips & Perron, 1988), and KPSS (Kwiatkowski *et al.*, 1992) test results are listed in Table no. 3.

Table no. 3 – Linear unit root tests

		ADF Test		PP Test		KPSS Test	
		Intercept	*Intercept and Trend*	*Intercept*	*Intercept and Trend*	*Intercept*	*Intercept and Trend*
Brazil	rs_t	-25.484***	-25.466***	-25.559***	-25.542***	0.057	0.059
	rf_t	-25.759***	-25.741***	-25.803***	-25.785***	0.057	0.058
Russia	rs_t	-26.145***	-26.150***	-26.144***	-26.148***	0.180	0.167*
	rf_t	-20.152***	-20.215***	-20.143***	-20.202***	0.181	0.027
India	rs_t	-25.285***	-25.273***	-25.296***	-25.283***	0.095	0.087
	rf_t	-25.132***	-25.120***	-25.140***	-25.127***	0.095	0.086
South Africa	rs_t	-25.855***	-25.860***	-27.527***	-27.929***	0.132	0.041
	rf_t	-25.771***	-25.773***	-27.771***	-27.73***	0.103	0.074
Turkey	rs_t	-26.456***	-26.478***	-26.449***	-26.470***	0.135	0.065
	rf_t	-26.121***	-26.115***	-26.190***	-26.201***	0.078	0.052

Note: The lag length for the ADF test was chosen based on the AIC criterion. PP and KPSS tests are estimated on a Bartlett-core basis using the Newey–West bandwidth. The null hypothesis of the ADF and PP tests is that the series is not stationary, while that of the KPSS test is that it is stationary against a unit root alternative. ***, **, and * indicate the statistical significance at the 1%, 5%, and 10% levels, respectively.

Sources: conducted by authors

Table no. 3 shows that the return series for both spot and futures prices are stationary according to the ADF, PP, and KPSS tests. After examining the unit root processes of the variables, Equation 1 is estimated using alternative estimators. The estimation results are presented in Table no. 4.

Table no. 4 shows the OHRs obtained by using this study's model. Diagnostic tests for each model are shown in the lower panel of Table no. 3. For each country, the β (OHR) of all models is statistically significant. Additionally, the coefficient of the error correction variable in the ECMs established for all countries was greater than 1 ($\delta < -1$).Narayan and Narayan (2005) state that the coefficient of the error correction variable is greater than 1 – the system reaches equilibrium by fluctuating. This fluctuation will decrease each time, and it will provide a return to equilibrium in the long run (Özçağ, 2015). Furthermore, *z* is negative and statistically significant in the ECMs for all countries. Consequently, the most appropriate models for all countries were determined at the end of the diagnostic tests – the ECM for Brazil, Russia, and South Africa and the GLS model for India and Turkey. Figure no. 2 shows the weekly time-varying OHRs according to the appropriate model for all countries.

Table no. 4 – Estimation results of fixed optimal hedge ratio according to alternative models

Depended Variable: rs_t			
Brazil	**OLS**	**ECM**	**GLS**
α	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
β	0.972*** (0.000)	0.967*** (0.000)	0.974*** (0.000)
δ		-1.187*** (0.000)	
Diagnostics Tests			
Breusch–Godfrey Test	24.122***	2.558*	0.845
B–P–G Test	4.117**	1.637	4.451**
Russia	**OLS**	**ECM**	**GLS**
α	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
β	0.965*** (0.000)	0.971*** (0.000)	0.986*** (0.005)
δ		-1.205*** (0.000)	
Diagnostics Tests			
Breusch–Godfrey Test	12.237***	1.109**	0.256
B–P–G Test	7.223***	0.231	12.836***
India	**OLS**	**ECM**	**GLS**
α	0.000 (0.731)	0.000 (0.991)	0.000 (0.600)
β	0.984*** (0.000)	0.988*** (0.000)	0.983*** (0.000)
δ		-1.356*** (0.000)	
Diagnostics Tests			
Breusch–Godfrey Test	14.524***	0.856	0.289
B–P–G Test	3.796*	7.400***	0.088
South Africa	**OLS**	**ECM**	**GLS**
α	0.000 (0.755)	0.000 (0.989)	0.000 (0.296)
β	0.965*** (0.000)	0.962*** (0.000)	0.986*** (0.005)
δ		-1.202*** (0.000)	
Diagnostics Tests			
Breusch–Godfrey Test	12.585***	1.024*	0.354
B–P–G Test	0.355	1.064	8.802***
Turkey	**OLS**	**ECM**	**GLS**
α	0.000 (0.925)	0.000 (0.992)	0.000 (0.889)
β	0.969*** (0.000)	0.972*** (0.005)	0.967*** (0.000)
δ		-1.248*** (0.000)	
Diagnostics Tests			
Breusch–Godfrey Test	21.588	4.585***	1.002*
B–P–G Test	8.254***	6.781***	0.571*

Note: β represents the optimal hedge ratios (OHRs), and δ represents the error correction coefficients. ***, **, and * indicate the statistical significance at the 1%, 5%, and 10% levels, respectively. Values in parentheses show standard errors of parameter estimates. *Breusch–Godfrey test* statistics were used for autocorrelation. The Breusch–Godfrey test null hypothesis is that there is no serial correlation in any order up to p. Breusch, Pagan, and Godfrey (B–P–G) test statistics were used for heteroscedasticity and the B-P-G test null hypothesis is that the error variances are equal.

Sources: conducted by authors

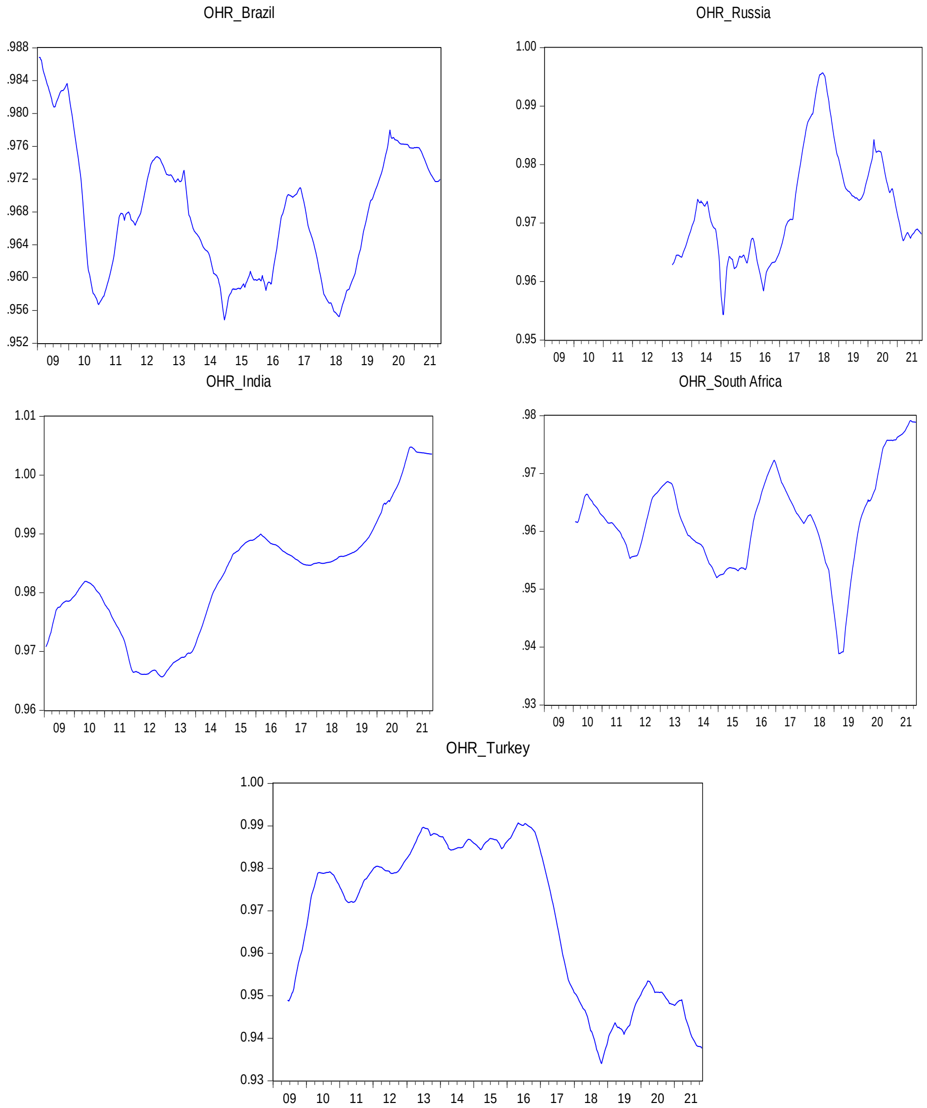


Figure no. 2 – Time-varying optimal hedge ratio (Multiple Graph)

Sources: conducted by authors

According to Figure no. 2, the hedge ratio increased after 2009 due to the effects of the financial crisis. However, the effects of the debt crisis that followed immediately were reflected in the graphs. In the period 2013–2015, the relationship between spot and futures prices decreased in Brazil, Russia, India, and South Africa, excluding Turkey. In Turkey, the hedge ratio – which remained high after the global crisis – started to decline after the coup attempt in 2016. Notably, the hedging efficiency of derivative transactions decreased due to the economic problems experienced in the following period and the volatility that ensued.

Based on the following path, we analyzed the interaction between the OHRs due to the variation in the countries' transition dates to the futures market. By determining the starting date according to Russia (May 5, 2013), we analyzed the structure of the relationship between the OHRs of all stock markets, first in Figure no. 3 and then in Table no. 4, via the correlation test approach.

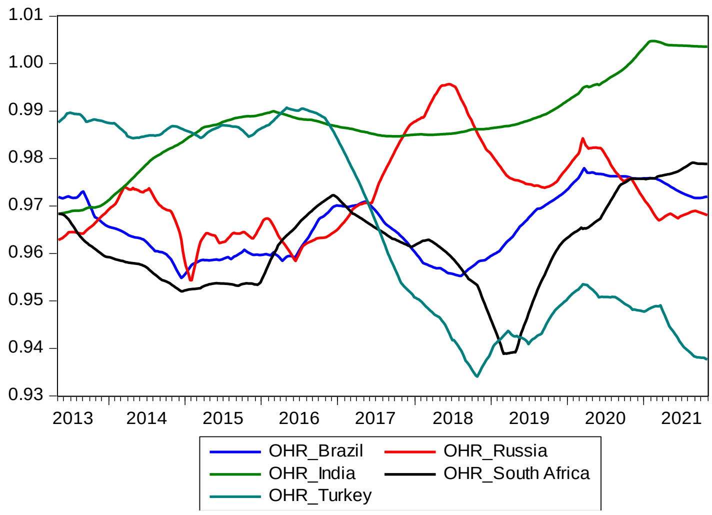


Figure no. 3 – Time-varying optimal hedge ratio (Single Graph)
Sources: conducted by authors

According to Figure no. 3, the OHR rates – which showed a similar trend until the first half of 2017 – diverged after the second half of 2017. The hedging effectiveness of Brazil, South Africa, and Russia show a similar trend in the next period. The hedging effectiveness of the futures market in India shows a better trend compared to other countries. However, owing to the local economic problems experienced in Turkey, its hedge ratio fell to the lowest level among these countries. After the demonetization of new banknotes in 2017, economic activities slowed down in India. Nevertheless, this situation led to the exclusion of black money from the system. During this period, increasing confidence in the financial markets had a positive impact on the markets, and the number of new investors trading in the markets increased. The presence of more investors in the market also led to market stabilization. Although the hedging efficiency level differs from one country to another, the lowest hedge ratio is above 0.93. This shows that the futures market can be effectively used in the risk management of spot market portfolios in all countries. Table no. 5 shows the results of the correlation analysis of the time-varying OHR rates for all countries.

Table no. 5 – Correlation between time-varying optimal hedge ratios.

	OHR_Brazil	OHR_Russia	OHR_India	OHR_South Africa	OHR_Turkey
OHR_Brazil	1.000				

OHR_Russia	-0.078*	1.000			
	(0.098)	-----			
OHR_India	0.397***	0.063	1.000		
	(0.000)	(0.182)	-----		
OHR_South Africa	0.666***	-0.109**	0.468***	1.000	
	(0.000)	(0.021)	(0.000)	-----	
OHR_Turkey	-0.263***	-0.706***	-0.564***	-0.091*	1.000
	(0.000)	(0.00)	(0.000)	(0.055)	-----

Note: ***, **, and * indicate the statistical significance at the 1%, 5%, and 10% levels, respectively. Values in parentheses show standard errors of parameter estimates.

Sources: conducted by authors

According to Table no. 5, Brazil's OHR is positively correlated with India and South Africa – at a significance level of 0.10 – while it is negatively correlated with Turkey and Russia. Furthermore, Russia's OHR is negatively correlated with South Africa and Turkey. Moreover, India's OHR is positively correlated with South Africa and negatively correlated with Turkey. Table no. 4 shows that Turkey's OHR was negatively correlated with the OHR of all countries. In particular, the correlation between Turkey and Russia is in the opposite direction and is at the highest (-0.706) level compared to other correlations. This shows that Turkey's internal dynamics are different from those of other countries in this study.

5. DISCUSSION

Stock investors are at risk because of the portfolios they create. Therefore, futures markets are crucial in hedging such risks. The hedging effectiveness of futures depends on their relationship with the asset to be hedged. In this study, the hedging effectiveness of the futures market was analyzed using the dynamic FLS method, aided by weekly closing data for the period from January 2009 to October 2021. The model results show that the hedge ratio is high for all the countries in the study. However, considering the hedge ratio for 2021, Turkey has the lowest hedge ratio. Notably, the hedge ratios decreased in 2018, 2019, and 2021 because of Turkey's exchange rate risk during the 2008 global crisis and after the coup attempt in 2016. During this period, the financial markets in the country had a considerably volatile structure. The literature reports that high volatility leads to a decrease in hedging effectiveness in markets (Buyukkara *et al.*, 2022). These findings differ from those of Gupta and Singh (2009); Anjana Raju and Velip (2018); Kaur and Gupta (2018) which show that linear models provide superior hedging. Because, used model and data type are vary from that of these studies. However, our findings are compatible with those of Çelik (2014); Gök (2016); Lakshina (2017).

This study's findings show that investors can use index-based futures to protect their portfolios. The changes that affect the effectiveness of hedging transactions, especially measuring the effectiveness of hedging in crisis environments, may be the subject of further studies. Moreover, the impact of volatility on hedging effectiveness can be investigated in future studies. Additionally, it will be useful to conduct research in both developed and developing countries to enable comparisons between the volatility effect on hedging effectiveness in developed and developing markets. There are some limitations; It has been used weekly data in the paper. If, it was used daily and monthly data together, we could compare to effectiveness of the different data type. We could also compare the volatility of daily, weekly and monthly data and see the effect of time. Because this paper focus on only stock spot indices and stock futures indices, it isn't possible to see the hedge effectiveness of other financial futures contracts. Therefore, it can be investigated and compared the other financial futures contracts effects in the further studies.

6. POLICY IMPLICATIONS

As previously addressed, futures transactions can be effectively used in the risk management of investors in spot stock markets. Actually, the lowest OHR is 0.93, and the OHRs of all countries are high. Thus, stock market investors in all countries can hedge their risks in spot markets. However, the lowest hedge ratio among the markets belong to the Turkish futures market. Moreover, Table no. 4 shows that the correlation coefficients between the OHR of the Turkish market and other markets are negative. The two findings imply that although the hedging capability of the Turkish market is adequate, it is the lowest among the markets analyzed herein. Additionally, investors in Brazil, Russia, India, and South Africa have a slightly better opportunity to hedge their risk through the futures market because of their higher OHRs than that of Turkey. Better hedging opportunities in any market encourage an investor to invest in the country. Investors in these countries can hedge their risk, thereby also contributing to the sustainability of stock markets.

Data Availability Statement

The data of this study are derived from investing.com. Data are public and can be imported directly from www.investing.com (01.11.2021).

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