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Analyzing Nexus between Crude oil, Gold, Dollar and Equity markets with Structural Break: ARDL Evidence from India

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ABSTRACT

This paper explores the price relations between the Crude oil, Gold, US dollar, and equities during several economic episodes. The long- and short-term causal relationships between asset markets are examined in this study. The research uses a 'Vector Error Correction Model (VECM)' and an 'Autoregressive Distributed Lag (ARDL)' bounds test to examine monthly data from April 1999 to March 2022. The results demonstrate the weak connections between asset markets throughout the different sample periods. Furthermore, the integration of most markets is uneven and changes over time. The currency and equity markets are adjusting to the long-run equilibrium only at a slow pace. We suggest that systematic risk factors must be taken into account while jointly modeling market linkages. This study improves on previous research in the subject by demonstrating the time-varying effects of asset price links on portfolio optimizations in different economic episodes.

Keywords: Oil, Gold, Dollars, Stock Returns, ARDL, VECM
JEL Classifications: C58; D53; F51; G15

1. INTRODUCTION

Commodity-finance nexus are attracting considerable academic interest in the light of its importance in strategic portfolio choices (Kilian and Park, 2009). However, most research in this area focus on the developed markets such as USA, UK and Japan. Only limited studies have investigated this issue in other developed and emerging markets (Singhal et al. 2019). Given the different political and economic structures, the risk-return profiles of the asset markets in developing or emerging world seem to be different (Arfaoui and Ben Rejeb, 2017). Hence, this study further extends the existing research to analyze the commodity-finance nexus within the context of an emerging market.

This study highlights the interdependencies between the dollar, gold, crude oil, and Indian equities markets. More specifically, research looks into the price integration between assets that possess significant diversification characteristics in an emerging market context. The aforementioned assets exhibit comparable statistical characteristics, notably in terms of their price dynamics (Parimi, 2018). According to Chakrabarti and Ghosh (2014), India has emerged as a prominent beneficiary of foreign funds. Additionally, Behera and Yadav (2019) have noted that India has a significant position as a big importer of oil and gold. The effect of pricing for commodities like gold and and oil, on financial asset prices is substantial and might potentially lead to financial instability, even within the robust US economy (Shahzad et al., 2019). The foreign exchange exposure of most emerging economies is significantly since they have to meet their consumption needs from global markets. Oil price shocks cause exchange rate volatilities (Hanson et al., 1993). Thus, an analysis of asset market linkages in India can help in identifying commonalities among the determinants of price trends prevailing in emerging economies.

Even while the asset market connection in India has been the subject of a few studies (Bhunia, 2013; Sobti, 2018; Hung, 2021; Saji, 2021b), a huge gap still remains, especially about the methodology used. For instance, even if the cointegration and causality approach have become well accepted in time- series analysis, research on commodity-finance market linkage in India mainly rests on the Johansen (1991) cointegration approach, which has been often criticized for its sensitivity to the lag length. Comparably, the lack of an attempt to address the problem of structural break is another significant drawback of the earlier studies. Similarly, another important limitation of the previous research is that they have not made any attempt to address the issue of structural breaks. Overlooking of the possibility of structural break might result in spurious inference (Phillips and Perron, 1988). Our study attempts to close this gap in light of these criticisms by employing a relatively novel estimate technique of the 'Autoregressive-Distributed Lag' (hereafter ARDL) approach to cointegration in the presence of structural breakup to analyze the commodity-financial market relationship.

The subsequent sections of the paper are structured in the following manner. In the next section, the existing literatures related to asset market linkages in different country context are reviewed. Section 3 explains the data, methodology, and model used. Section 4 discusses the estimation outputs and tests the robustness of the results. The research is finally concluded in Section 5.

2. LITERATURE REVIEW

Some existing literature examines the co-movement, cointegration, and lead-lag relationship among oil, dollar, stock and gold prices, but almost every work does it with a different design. Some of the researchers attempt to explore the potential long-run relationship between the sampled assets for their study, while others confine their studies to focus on the short-run price dynamism among assets. Most of the analysis use traditional time series models to study inter market linkages, but there are only a few studies use robust econometric approach.

Previous research, such as the study conducted by Wei (2003), did not yield statistically significant evidence of a causal linkage between stock and oil prices across different market environments. Shaeri and Katircioğlu (2018) conducted a research in which they discovered that crude oil price changes had a substantial effect on the long-term dynamics of equity prices particularly for transporting industry in the United States. Arfaoui and Ben Rejeb (2017) show inverse price correlation between equity and crude oil markets during a relatively more extended sample period of 1995-2015. Their study suggests that Investors are driven by the motivation to seek gold as a secure investment in order to mitigate their risks. According to Singhal et al. (2019), there exists positive linkage between international gold prices and stock prices, but the price relationship between oil and stock markets is negative. Sahu et al. (2014) show that an upward movement in oil price has small, but increasing effects on Indian equity prices in the short run. In a most recent research, Akhtaruzzaman et al. (2020) find inverse relations between intraday gold and international equity returns during certain months of the COVID–19 pandemic (January to March, 2020), indicating that 'gold is a safe haven asset for stock markets'.

There is empirical literature that explains the bi-directional causality between oil and currency prices. Brahmasrene et al. (2014) reveal that there exists a substantial inverse association between exchange rates and oil prices in the short term. Conversely, they observed that rises in oil prices have a large beneficial effects on exchange rate movements in the long term. According to Singhal et al. (2019), fluctuations in crude oil prices have a negative impact on currency movements in developing countries over an extended period of time. Some existing researchers have already looked into co-movement between gold and crude oil prices. Cashin and McDermott (2002) test the correlations between gold and oil prices and their empirical results reveals the evidence of significant price linkages between gold and crude oil markets. One can find long-term price equilibrium between the oil and gold markets (Zhang and Wei 2010). On comparing the price relations between the two markets, the contribution of the oil price appears to be higher. Several studies (Hooker, 2002; Gokmenoglua and Fazlollahia, 2015) explain causality between gold and crude oil markets through the 'inflation channel'.

Capie et al. (2005) demonstrate that gold is a good hedge for currency risks, but exchange rate cannot account for price volatility in gold market. However, the observations of Joy (2011) are quite opposite in this regard. Kilian and Vega (2010) investigate the effects of news on the price behavior of metals like gold. Their research shows that news generates stochastic trends that may propagate diverse impact on gold prices. Singhal et al. (2019) argue that within an emerging market context, the exchange rate is not significantly influenced by fluctuations in the price of gold. Sathyanarayana et al. (2018) conclude that the price volatilities in currency, gold and oil markets have the power to transmit shocks on the equity prices of emerging markets like India.

3. DATA AND MODEL

3.1. Data

Our data constitute monthly closing prices of Nifty 50, Gold and Brent crude oil markets; and monthly average of the nominal exchange rates (NER) of USD against INR from April 1999 to March 2022. The databases of St. Louis Fed and NSE respectively provide the data on crude oil prices, and Indian stock prices. We access Reserve Bank of India (RBI) database for the gold and dollar prices. Each pricing data series is log-transformed and expressed in rupees.

3.2. Model

Our study examines the long-term equilibrium connection and short-term price dynamics in the four asset markets. Our study primarily relies on the ARDL bounds testing technique. The utilization of the limits testing technique is supported by the presence of differing delays in explanatory variables and the constraint of a restricted sample size, particularly when dealing with sub samples.

3.3. ARDL Model

Pesaran et al. (2001) developed ARDL approach, which has been employed in this research for estimating the price relationship. For applying ARDL estimation technique, there is no condition of variables should be integrated of the same order. ARDL assumes the same lag length for all variables or various orders of lag without affecting the test statistic's asymptotic distribution (Pesaran et al., 2001). This estimating approach uses suitable lags to generate data in a general-to-specific model context. A simple linear transformation yields ARDL's dynamic error correction model. Moreover, cointegration analysis of small and finite sample sizes with ARDL test produces robust results.

One can estimate ARDL under an 'Ordinary Least Squares (OLS) regression framework' with different lags of the dependent and explanatory variables (Saji, 2021a). A generic ARDL (p,q) model can be written as:

$$Y_t = \alpha + \sum_{i=1}^{p} \Delta_i Y_{t-i} + \sum_{j=1}^{k}\sum_{i=0}^{qj} X_{j,t-i}\beta_{j.i} + \varepsilon_t \quad (1)$$

In equation (1), 'p' is the number of lags of the variable 'Y', the endogenous variable and 'q' is the number of lags of the variable 'X', the explanatory variable.

We have employed all dynamic regressors in our ARDL estimate, enabling non-zero lagged factors for the endogenous variables. The model is chosen and its lag duration is ascertained by the study using the 'Akaike information criterion (AIC)'. The dynamic error correction model (ECM) may be derived from the ARDL bounds test with the use of a straightforward linear transformation. Equation (2) yields the short-run dynamic parameters connected with the long-run estimations through the estimation of an unconstrained or conditional ECM.

$$\Delta Y_t = \sum_{i=1}^{p-1} \Delta_i \Delta Y_{t-1} + \sum_{j=1}^{k}\sum_{i=0}^{qj-1} \Delta X_{j,t-i}\beta_{j.i} + \alpha ECT_{t-1} + \varepsilon_t \quad (2)$$

The parameter indicating the speed of adjustment, 'ECT' directs what amount of the long-run disequilibrium in the model is corrected. The coefficient with a negative sign of less than unity is showing price convergence while a positive coefficient denotes explosive and is unreasonable.

Next we convert equation (2) into:

$$\Delta Y_t = \sum_{i=1}^{p-1} \Delta_i \Delta Y_{t-1} + \sum_{j=1}^{k}\sum_{i=0}^{qj-1} \Delta X_{j,t-i}\beta_{j.i} + \rho Y_{t-1} + \sum_{j=1}^{qk} \Delta X_{j,t-i}\delta_j + \varepsilon_t \quad (3)$$

Equation (3) provides for testing the null hypothesis of non-existence of long-term relations between asset markets.

H_0: $\delta_1 = \delta_2 . \delta_k = 0$

We compute F-statistic (given by Wald test), and the lower and upper bound critical values of Pesaran et al. (2001) determines its significance. Thereafter the goodness of fit of the model is decided by diagnostic and stability tests.

3.4. Causality Tests

After confirming the presence of cointegration between asset markets, VECM Granger causality approach explores the direction of causality (Granger, 1969). The model limits the long-run relationships between the price series, and VECM is a limited version of unrestricted VAR. When estimating, ECM treats every price series as endogenous. "This model permits the predicted variables to self-explain through their own lags, predictor lags, error correction term lags, and residual term lags." We model VECM equations as:

$$\begin{pmatrix} \Delta LNifty_t \\ \Delta LCrude_t \\ \Delta LDollar_t \\ \Delta LGold_t \end{pmatrix} \begin{pmatrix} C_1 \\ C_2 \\ C_3 \\ C_4 \end{pmatrix} + \sum_i^p \begin{pmatrix} \beta_{11i} & \beta_{12i} & \beta_{13i} & \beta_{14i} \\ \beta_{21i} & \beta_{22i} & \beta_{23i} & \beta_{24i} \\ \beta_{31i} & \beta_{32i} & \beta_{33i} & \beta_{34i} \\ \beta_{41i} & \beta_{42i} & \beta_{43i} & \beta_{44i} \end{pmatrix} \begin{pmatrix} \Delta LNifty_{t-1} \\ \Delta LCrude_{t-2} \\ \Delta LDollar_{t-3} \\ \Delta LGold_{t-4} \end{pmatrix} + \begin{pmatrix} \Upsilon_1 \\ \Upsilon_2 \\ \Upsilon_3 \\ \Upsilon_4 \end{pmatrix} ECM_{t-1} + \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \end{pmatrix}$$

Where 'ε_{it}' is a 'random error term' normally distributed with zero mean and unit variance. The C's, β's and ϒ's are the parameters to be estimated. ECM_{t-1} denotes the one month lagged error-term emerges from the cointegration vector. Here, the direction of any causal relationship between the variables is investigated using the F test.

4. METHOD AND EMPIRICAL RESULTS

4.1. Test of Stationarity

"ARDL can be applied when underlying variables are I(0), I(1) or fractionally integrated" (Pesaran et al., 1999). In order to make sure that none of the variables are integrated of order 2 or higher, the 'Elliott-Rothenberg-Stock DF-GLS (DF-GLS)" unit root test is used. Table 1 presents the results of unit root tests.

The unit root test results demonstrate that only crude oil prices show stationary properties at the level. Nevertheless, the results reported reveal that nifty, dollar and gold prices have unit roots at level, hence become stationary at their first differences. Thus, the results established that the observed asset price variables are a combination of I (1) and I (0) variables.

The standard stationary test that proposes the non-rejection of a unit root can be suspected once the underlying sample series integrate economic events can cause regime shift (Lee and Chang, 2005). There may be chances of a 'structural break' in trend (see Figure 1). Thus, to deal with the problem of 'structural breaks', this research has administered Zivot and Andrews (ZA) and Perron breakpoint unit root tests. These tests can endogenously correct for one 'structural break'. The results are presented in Table 2.

When a potential break in the data set is taken into consideration, Table 2 shows that the ZA and Perron tests, similar to the conventional unit root test, indicate that the oil price variable

Figure 1: Plots of Nifty, Dollar, Oil and Gold

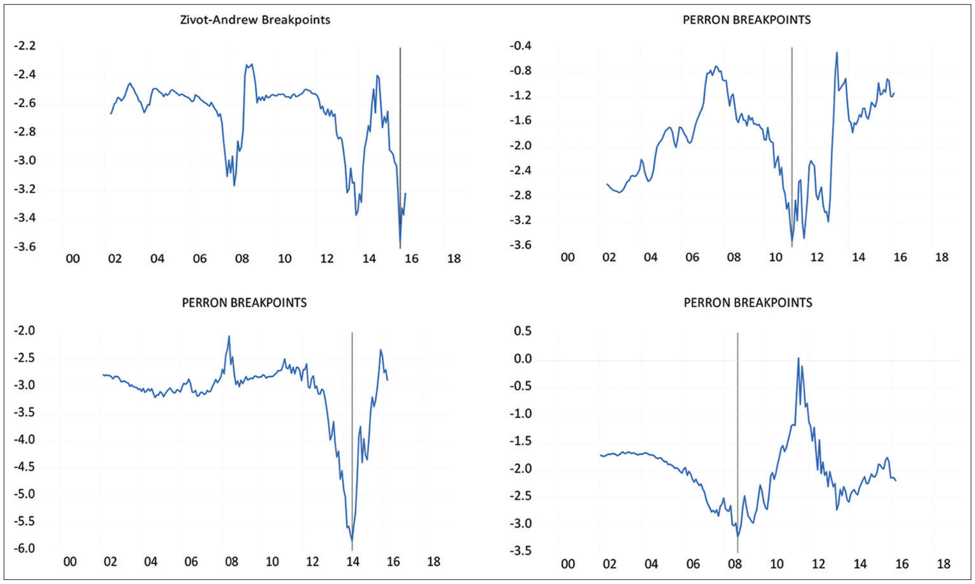


Table 1: Unit Root Test Results

Variables	Elliott-Rothenberg-Stock DF-GLS test statistic			
	Level		First Difference	
	With intercept	With trend and intercept	With intercept	With trend and intercept
Nifty	1.4814	-2.4523	-1.9460**	-5.0965*
Dollar	0.6928	-1.4618	-13.4663*	-13.4662*
Oil	-2.2079**	-2.6852***	-10.4779*	-10.4734*
Gold	1.9867**	-1.1539	-4.2966*	-13.1716*

Source: Author's Compilations Critical values of DF-GLS statistics (with intercept only) at 1%, 5% and 10% levels respectively are -2.5746; -1.9421 and -1.6158. Critical values of DF-GLS statistics (with intercept and trend) at 1%, 5% and 10% levels respectively are -3.4642; -2.9216 and -2.6253 *Significant at 1% level **Significant at 5% per cent level, ***Significant at 10% per cent level

exhibits stable features at the level. The result shows that the structural change in crude prices took place from mid-2014 when there was growing supply glut reinforced by weakening demand prospects and booming US shale oil production. The impact was greater on the Indian economy because the October 2014 deregulation of diesel and formalisation of the natural gas price formula by the newly elected NDA government free the country from the fuel subsidy system. However, the null hypothesis of a unit root is not rejected for nifty, dollar and gold at level. ZA and Perron test results find that there is a break point occurring in gold in 2008 and in dollar in mid-2011. To justify these break points, this research finds some critical political and economic events during 2008–2015. The break point in gold in 2008 can be attributed to ‘the global financial crisis where the impact of the ‘investor meltdown’ hit the yellow metal prices too’. The year 2011 was disastrous for rupee due to a number of factors including the ‘rising demand for the dollar, the worsening domestic economic scenario and sustained capital outflows’. Hence, it seems possible that the structural break in dollar in India took place in 2011. According to ZA and Perron unit root test results, the break points in nifty are occurred in 2015, possibly a result of the economic recoveries, expectations about the newly formed government, strong foreign capital inflows, revival of manufacturing, improved macro-economic conditions and possibly a rise in corporate earnings growth. We use these breakpoints to split the entire sample time into three panels. Panel A goes from 1999 to 2008, Panel B from 2009 to 2014, and PanelC from 2015 to 2022. In order to quantify the long-term and short-term effects of the price linkages across all markets, we re-estimate all the models that were developed for this study using each subsample data, as well as the whole sample period of panel D.

4.2. ARDL Cointegration

The computed F-statistics from ARDL cointegration modelling, are reported in Table 3. Here, we consider every asset price variable as a dependent variable (normalized). From the results reported, it is obvious that there is conclusive evidence of at least one long-run relations exists amongst the asset price series in each of the panels selected. We ultimately reject the null hypothesis of no cointegration among price series.

While we estimate cointegration with crude as dependent variable (Model 2), corresponding F statistics posit above upper bounds at least at 5% level in all panels, which imply the conclusive evidence of long-run relations of the oil price with other asset markets irrespective of the business cycles. Similarly, the cointegration estimation with nifty (Model 1) in Panel C produce the evidence of long run integration of Indian stock markets with the price movements in alternative investment markets during recovery days. When we estimate dollar as dependent variable (Model 3) in sub sample periods, gold (Model 4) in Panel A and Panel D, and nifty (Model 1) in Panel D, their respective F-statistics fall between the lower and upper-bounds at 5% level. Such results acknowledge the inconclusive evidence of long-run relations of the prices of these assets with other price series. Since the values of F statistics from ARDL estimations are much below the bound statistics at all significance levels, the cointegration estimations using rest cases have not revealed any indication of cointegration among asset markets. Therefore, for these regressions, we were unable to quantify the causal relationships inside dynamic ECM.

Table 2: Unit Root Tests with One Break: Zivot-Andrews test & Perron test

Variables	Zivot-Andrews test			Perron test		
	t - statistic	Month of break	Result	t - statistic	Month of break	Result
Nifty	-3.5524	2015M04	Non- stationary	-3.5129	2015M03	Non- stationary
Dollar	-3.8167	2011M08	Non- stationary	-3.8108	2011M07	Non- stationary
Oil	-5.7206*	2014M10	Stationary	-5.6976**	2014M9	Stationary
Gold	-3.2461	2008M09	Non- stationary	-3.2073	2008M08	Non- stationary

Table 3: Estimated ARDL models and bounds F-test for cointegration

Panel	Models	ARDL Equation	Optimal Lag	F Statistic	Decision	χ^2 NORM	χ^2 ARCH	χ^2 SERIAL	χ/RESET
Panel A	1	F_{Nifty} (crude, dollar, gold)	(1,0,1,0)	2.023	No cointegration	1.1286	0.741	3.280	1.652
	2	F_{Crude} (nifty, dollar, gold)	(1,0,1,1)	4.212	Cointegration	2.338	0.918	1.812	2.287
	3	F_{dollar} (nifty, crude, gold)	(1,0,1,1)	3.249	Inconclusive	18.324*	2.315	0.164	1.192
	4	F_{Gold} (nifty, crude, dollar)	(1,1,0,1)	3.032	Inconclusive	46.229*	2.367	0.283	1.449
Panel B	1	F_{Nifty} (crude, dollar, gold)	(1,0,1,0)	2.376	No cointegration	4.486	0.167	0.311	0.1788
	2	F_{Crude} (nifty, dollar, gold)	(1,0,0,0)	5.420	Cointegration	2.402	1.015	2.523	0.111
	3	F_{dollar} (nifty, crude, gold)	(1,0,1,0)	3.031	Inconclusive	1.078	0.920	2.661	1.006
	4	F_{Gold} (nifty, crude, dollar)	(1,0,0,1)	1.945	No cointegration	8.393*	0.004	1.472	1.914
Panel C	1	F_{Nifty} (crude, dollar, gold)	(1,0,1,1)	5.152	Cointegration	3.856	2.808	2.233	0.011
	2	F_{Crude} (nifty, dollar, gold)	(1,1,1,0)	3.873	Cointegration	0.155	0.365	2.718	0.672
	3	F_{dollar} (nifty, crude, gold)	(1,0,1,0)	3.499	Inconclusive	4.181	0.112	0.638	2.175
	4	F_{Gold} (nifty, crude, dollar)	(1,0,1,0)	1.912	No cointegration	0.009	3.545	0.616	0.155
Panel D	1	F_{Nifty} (crude, dollar, gold)	(1,1,1,1)	3.073	Inconclusive	31.581*	0.059	1.585	1.177
	2	F_{Crude} (nifty, dollar, gold)	(1,1,1,0)	4.499	Cointegration	5.469	0.198	0.986	1.743
	3	F_{dollar} (nifty, crude, gold)	(1,0,1,1)	2.393	No cointegration	27.209*	2.518	4.432	0.0496
	4	F_{Gold} (nifty, crude, dollar)	(1,1,1,0)	2.916	Inconclusive	20.611*	0.112	3.273	2.932
Critical Value Bounds		Lower bound I (0)		3.65*	2.79**	Upper bound I (1)		4.66*	3.67**

*Significant at 1% level **Significant at 5% per cent level

All of the usual tests that were advised for the residual and stability diagnostics were passed by our estimating models. To be more precise, there are no problems with residual heteroscedasticity, serial correlations, or normalcy, especially for the estimates that show a cointegrated structure in asset prices. There is no difficulty with nonlinearity in our estimate models since the p values of the Ramsey's Regression Equation Specification Error Test (RESET) tests are high. As such, the functional form of our estimate is precise and free of problems related to missing variables.

Finding a long-term association between economic variables may also be accomplished efficiently by testing the relevance of a negative lagged error-correction term.This is particularly important when the ARDL estimation produces inconclusive cointegration. Hence, we estimate the causal relationship within dynamic ECM for those regression estimations producing conclusive/inconclusive evidence of cointegration. When the gold prices rise by 1%, this will cause the crude prices to increase by 0.78%, 4.92% and 0.68% in Panel A, Panel C and Panel D respectively (Table 4). We observe significant responses from gold prices to crude oil prices during pre-recession period. Similarly, for every 1% increase in equity prices, there is 1.20% increase in crude prices for Panel B. A 1% increase in gold prices will result in a 2.36% increase in equity during economic recoveries and 1.22% in full sample period. The responsiveness coefficients of dollar rates towards other asset prices are found significant only in Panel A where 1% increase in equity prices and gold prices correspondingly lead to a 0.40 per cent dollar depreciation and 0.28 percent dollar appreciation against Indian rupee. Thus, there are direct relationships between asset prices, but is time varying for the case of India.

In order to calculate the short-run dynamic parameters, an error correction model for the long-run estimations of regressions must now be estimated (Narayan and Smyth, 2009). The models are estimated using an error-correction factor in cases where there is insufficient evidence to reject the null hypothesis of market cointegration. We note that nifty prices have significant and inverse impact on dollar prices in three sub sample periods (Table 5). Likewise, dollar influences nifty negatively and significantly. The impact of dollar on crude (except in recessionary phase) and gold prices (in Panel A and Panel D) are positive and significant. The crude price changes hold significant dynamic elasticity with gold price variations on a short run basis in Panel D. Upon thorough examination, it becomes evident that the effects of asset markets occur simultaneously with one another. All of the models have error correction coefficients that are significant even at the 1% level and are negative as needed. This demonstrates that the calculated variables have a well-established long-term connection. The dynamics may have converged from the short-run to the long-run equilibrium, confirming the system's stability, according to the statistical significance of the ECMt-1. When the error correction terms of crude are compared to those of other commodities, it is evident that the rate of correction of the divergence of its prices from the long-run equilibrium is considerably higher. Other asset markets' extremely low error correction term values make it clear that it will take a very long time for price changes to fix the disequilibrium in those markets.

Table 4: Estimated long-run coefficients for Nifty, Crude, Dollar and Gold prices using the ARDL approach

Variables	Panel A			Panel B		Panel C			Panel D		
	Crude	Dollar	Gold	Crude	Dollar	Nifty	Crude	Dollar	Nifty	Crude	Gold
Constant	1.863 (0.764)	6.417* (0.001)	-3.316 (0.690)	-2.168 (0.662)	3.552* (0.001)	-11.853 (0.153)	-30.801 (0.106)	2.396 (0.445)	-1.558 (0.693)	6.214 (0.000)	66.554** (0.012)
Nifty	0.289 (0.325)	-0.002 (0.493)	0.281 (0.461)	1.156** (0.033)	-0.408* (0.001)	-	0.059 (0.944)	0.134 (0.433)	-	0.254 (0.181)	1.308 (0.307)
Crude	-	0.266 (0.149)	0.795 (0.085)	-	0.082 (0.395)	0.386 (0.117)	-	0.093 (0.375)	-0.172 (0.795)	-	-0.225 (0.849)
Dollar	-1.083 (0.501)	-	1.371 (0.479)	-1.356 (0.335)	-	-2.081 (0.307)	-3.887 (0.117)	-	-0.292 (0.841)	-1.904* (0.000)	-2.613 (0.583)
Gold	0.775** (0.036)	-0.361 (0.285)	-	0.541 (0.177)	0.283* (0.000)	2.357 (0.054)	4.921** (0.045)	-0.013 (0.445)	1.217 (0.068)	0.677* (0.001)	-

Source: Author's Compilations *Significant at 1% level **Significant at 5% per cent level

The CUSUM and CUSUM of squares statistics for Equation (3) are presented in Figures 2-5. Figure illustrates how the plots of the CUSUM and CUSUMSQ statistics remain within the critical 5% boundaries, indicating that the long-term correlations between the variables are confirmed and that the coefficients of models where cointegration is conclusive are stable. Nevertheless, CUSUMSQ data show instability of the coefficients for the equations of dollar (in Panel C) and nifty (in Panel D), where the cointegration is determined to be inconclusive, since they beyond the 5% critical boundaries of parameter stability.

4.3. Granger Causality

The presence of cointegration for equity, crude, dollar and gold prices in certain panels lead us to implement the VECM Granger causality approach to analyze the direction of causal relationship between the series. The proper knowledge on the direction of causality between the asset prices helps investors in return optimizations through enhancing portfolio efficiencies in long run. The Granger causality test through ECM may be decomposed into short-run and long-run causalities and assessed in three possible ways. First, determining the significance of the sum of the lagged differences of the explanatory variables using the F-statistic allows one to verify the short-run causality. Secondly, t-statistics-based coefficients of the Ect_{t-1} may be used to directly verify long-run causation. Once this coefficient turns negative and becomes statistically significant, we infer that long-run Granger causation occurs. Lastly, the joint hypothesis may be tested using the F-test on both Ect_{t-1} and the sum of lagged differences of explanatory variables to investigate the strong Granger causality. Table 6 provides a summary of the causality test results.

Results of causality tests endorse the presence of short-run price relations running from dollar to gold in Panel A and Panel D, and to nifty in Panel C. Similarly, the unidirectional causality is running from equity prices to crude oil market in Panel B and Panel D. The impact of gold price changes cause price variations to dollar and equity market during recovery stage (Panel C). The research hardly finds the evidence of short run reverse with respect to these variables. We cannot not notice the existence of bi-directional causality in any of the asset pairs. Looking at the long-run causality, the 'ECT_{t-1}' coefficients are negative and statistically significant for the error correction models of crude prices talking about causal flows among variables in all panels. Indeed, long-run causality exists for the equations of Nifty in Panel C and Gold in Panel B and Panel D, but not for dollar prices. Although, 'ECT_{t-1}' coefficients are statistically significant for gold prices in certain panel, their inverted signs restrict us to assume the chances of any kind of long-run causality from the concerned equations. A close observation reveals that the dependency on price movements across many asset markets is time-varying and asset specific in India.

The significance of causality coefficients indicate that currency market is relevant in influencing the price trends in commodity market, both gold and oil market, despite their effects are inconsistent across sample periods. Our findings corroborate the claims of Kat and Oomen (2006) who have produced the evidence of commodity wise differences in the causal relations among asset

Figure 2: CUSUM and CUSUMSQ Plots for Stability Test: Panel A

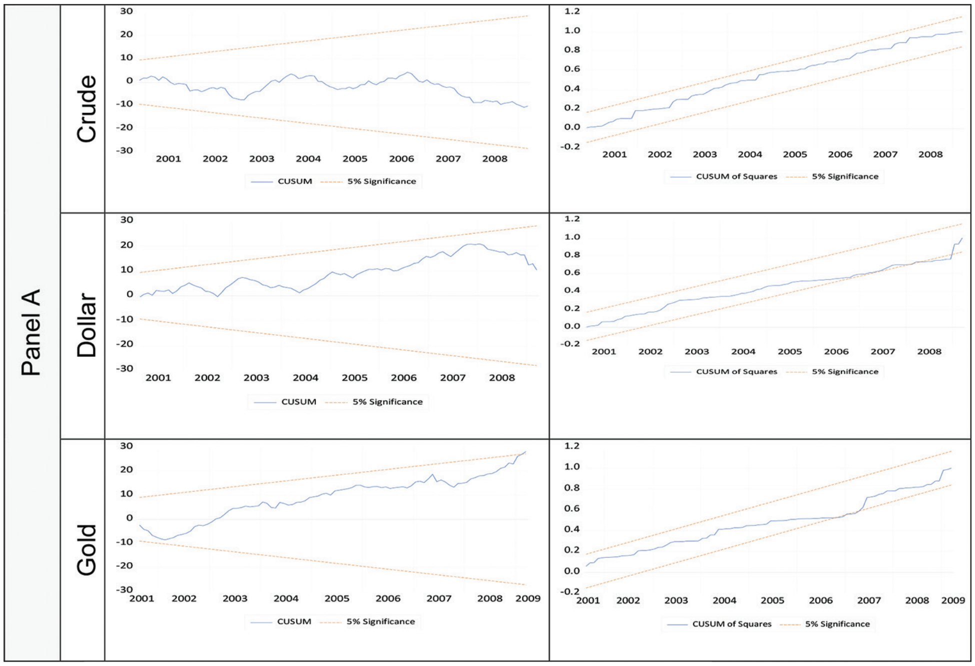


Table 5: Estimated short-run coefficients for Nifty, Crude, Dollar and Gold prices using the ARDL approach

	Variables	Δ Nifty	Δ Crude	Δ Dollar	Δ Gold	ECT(-1)
Panel A	Crude	-		1.419** (0.040)	0.394** (0.020)	-0.169* (0.000)
	Dollar	-0.056* (0.000)			0.047 (0.028)	-0.051* (0.000)
	Gold	0.171* (0.005)		0.841** (0.026)		-0.063* (0.000)
Panel B	Crude	-				-0.162* (0.000)
	Dollar	-0.214* (0.000)				-0.160* (0.000)
Panel C	Nifty			-1.261* (0.000)	-0.107 (0.390)	-0.079* (0.000)
	Crude	0.585 (0.071)		1.391 (0.084)		-0.140* (0.000)
	Dollar	-0.241* (0000)				-0.098* (0.000)
Panel D	Nifty			-15.230* (0.000)		-0.013* (0.000)
	Crude	0.219** (0.023)		0.493 (0.099)		-0.105* (0.000)
	Gold		0.039 (0.175)	0.309** (0.012)		-0.001* (0.000)

*Significant at 1% level **Significant at 5% level, Stability tests

Table 6: Short-run and long-run causality tests

		Short run causality				Long run causality
Endogenous Variables		Δ $Nifty_{t-1}$	Δ $Crude_{t-1}$	Δ $Dollar_{t-1}$	Δ $Gold_{t-1}$	ECT_{t-1}
Panel A	Crude	-0.122 (0.903)	-	0.498 (0.618)	0.418 (0.676)	-3.848* (0.000)
	Dollar	-0.517 (0.605)	0.393 (0.694)	-	0.090 (0.928)	-0.519 (0.608)
	Gold	0.913 (0.362)	1.048 (0.295)	2.076** (0.038)	-	-0.538 (0.590)
Panel B	Crude	2.328** (0.022)	-	0.819 (0.413)	-0.457 (0.648)	-3.260* (0.001)
	Dollar	0.637 (0.524)	-0.778 (0.437)	-	1.063 (0.288)	1.509 (0.132)
Panel C	Nifty	-	1.244 (0.215)	-2.785* (0.006)	2.233** (0.024)	-2.345** (0.019)
	Crude	0.581 (0.562)	-	0.507 (0.612)	1.203 (0.230)	-2.738* (0.007)
	Dollar	1.435 (0.152)	0.565 (0.572)	-	-1.805*** (0.072)	0.251 (0.802)
Panel D	Nifty	-	0.774 (0.439)	-0.769 (0.442)	-0.068 (0.945)	0.152 (0.878)
	Crude	1.867*** (0.063)	-	0.748 (0.455)	-0.032 (0.974)	-5.020* (0.000)
	Gold	0.061 (0.951)	0.357 (0.721)	1.908*** (0.057)	-	1.975** (0.049)

*Significant at 1% level **Significant at 5% per cent level, ***Significant at 10% per cent level

markets. Interestingly, the analysis finds more amounts of causality across markets during the post-recession period. We can attribute two arguments as the cause of the increased linkages between commodity and financial markets. One is due to the financialization of commodities as discussed by Tang and Xiong (2012). Indian started commodity trading through commodity exchanges in 2003 and currency trading through stock exchanges in 2008 onwards, and the process could be resulted in a more significant correlation between stocks and commodities due to increased investor involvement in markets. The second explanation for the time-varying causality between assets markets in India is that in lousy time investors show higher risk aversion, and investors

Figure 3: CUSUM and CUSUMSQ Plots for Stability Test: Panel B

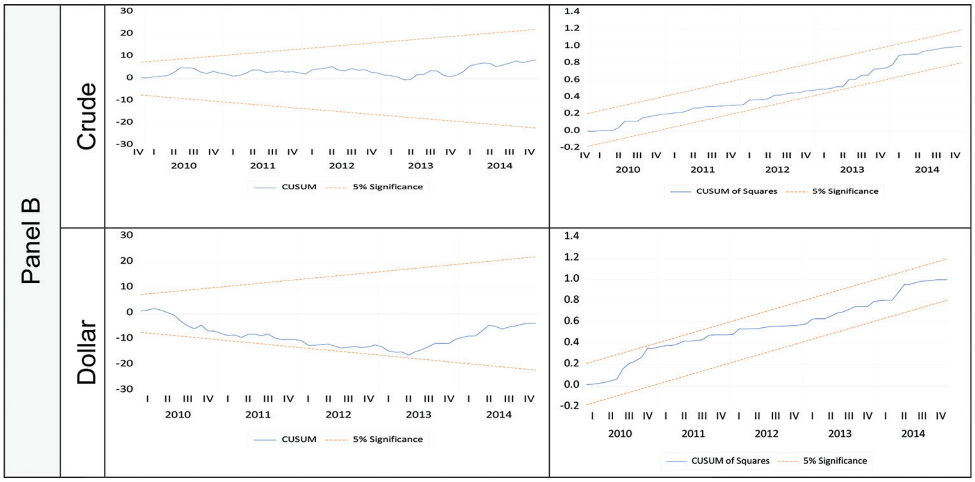


Figure 4: CUSUM and CUSUMSQ Plots for Stability Test: Panel C

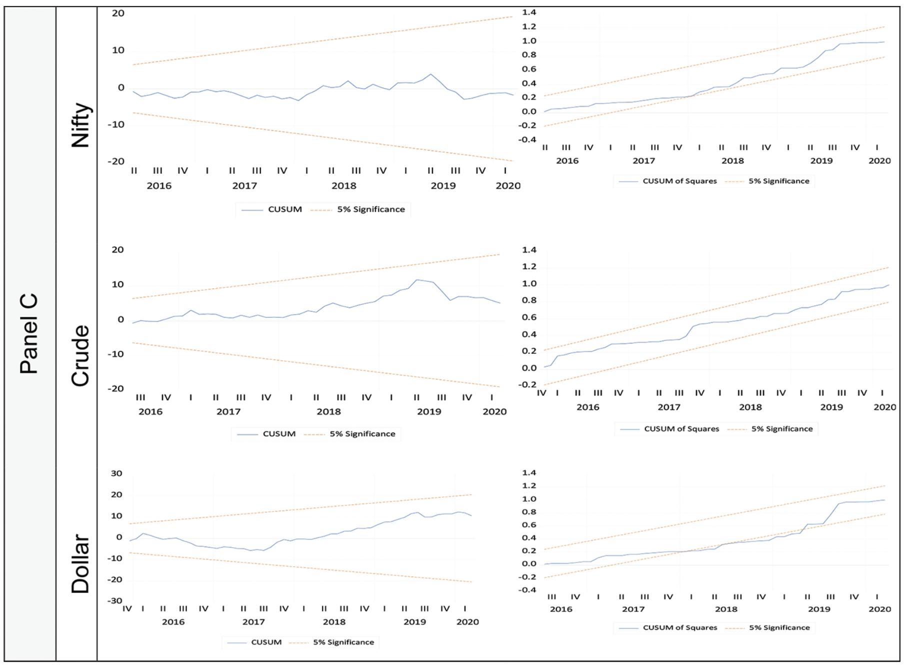
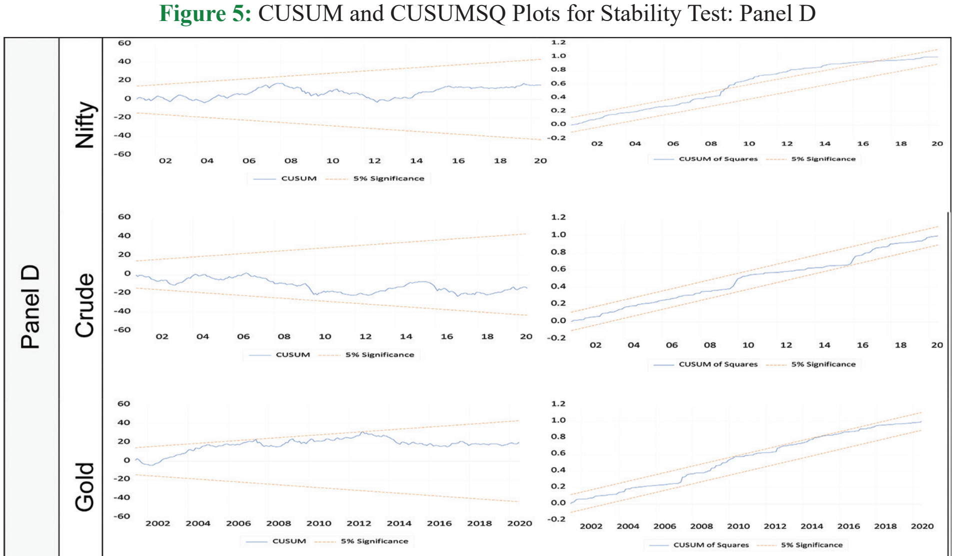


Figure 5: CUSUM and CUSUMSQ Plots for Stability Test: Panel D



force to move out of risky assets as a group leaving risky assets to be high correlated.

5. CONCLUSION

This research aims to investigate the price integration between the commodity and financial markets across different sample periods. Main findings confirm the presence of long-run relations between commodity and financial markets. However, the speed of adjustment to the long-run equilibrium is lower for the financial markets compared to their commodity counterparts. Moreover, Granger causality results indicate significant variations in the causal relations among variables across the sample periods. Short-run causality is unidirectional, while long-run Granger causality is not found in certain markets, especially running neither from equity prices nor from crude prices to exchange rates. Also, short-run causality does not exist between crude and gold prices in any of the sample periods. However, more evidences of causality are revealed for nifty prices during the most recent sample period, particularly from dollar and gold prices. Accordingly, the exchange rate lead stock prices support the 'Good market hypothesis' and is consistent with the findings of Tabak (2006) and Arfaoui and Ben Rejeb, (2017). There is no short-run causal link from the nifty to the gold price, but there is unidirectional causation that goes from equities prices to gold prices, which is consistent with earlier research by Shiva and Sethi (2015). In the light of this findings, we can say that gold plays a diversifier role rather than a hedging role in Indian stock markets. This lends partial support to previous findings in the literature (Akhtaruzzaman et al., 2020) that observed gold as a safe haven for stock investments.

The findings of this research merit significance for portfolio managers in their wealth management. The information on weak price integration among asset markets provides valuable insights for investors and portfolio managers about profit potentials of various asset mixes. However, time-varying asset market linkage with the presence of 'structural breaks' in price distributions may suggest investors to adopt an active investment style that align their strategies with prevailing market conditions. This finding perfectly agrees with the observation of Slimane et al. (2020) who suggest that the investors should be cautious of the change in the level of market integration while making their portfolio choices. However, the lack of evidence of strong market integration may evolve a policy paradox while combating market disequilibrium through interventions and regulations.

Obviously, the current findings can be an excellent way to understand the short-run as well as long-run linkages among four asset classes. However, we cannot warrant the replication of the trend in future. All analyzed markets generate data in much more frequent range than monthly frequency. Taking over to monthly data that we use may significantly disturb the inference, and even affect adversely the conclusions. Many factors extraneous to the scope of research such as additional oil sources, alternative resource discoveries, changing global economic landscape and the evolving geopolitical trends, all can be substantial in determining the factors affecting the interdependent asset market structure. The degree of equity market integration with other asset markets can mostly be sector-specific, which our research did not consider. Hence, an extension to this study with high frequency data that investigates the impact of the price changes in different asset markets on the sectoral stock price indices in other emerging markets can offer more valid and useful policy making.

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