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International equity and bond market dynamics an asymmetric error correction study of united states, india and brazil

Munawar Sayyad
IFHE (ICFAI Foundation For Higher Education) University, IBS Hyderabad

Pat Obi
Purdue University Northwest

Kaushik Bhattacharjee
IFHE (ICFAI Foundation For Higher Education) University, IBS Hyderabad

Abstract

Using the recently developed nonlinear autoregressive distributed lag (NARDL) model, this study examines the dynamic linkages between bond and equity markets over an extended period that encompasses the time from March 2016 to November 2020. Financial market variables were obtained for U.S., India, and Brazil, three large economies at different stages of economic development. The target variable is the slope of the yield curve, measured as the yield difference between 10-year and 3-month government bonds. Equity market variables are stock returns and implied volatility. A pre-post examination of the slope shows that the distributional properties of the variables changed markedly over the sample period. However, empirical results confirm cointegration but with significant nonlinearities. Policy recommendations on targeted fiscal intervention and asset allocation are offered.

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Contact: Munawar Sayyad - munawar0013@ibsindia.org, Pat Obi - obi@pnw.edu, Kaushik Bhattacharjee - kaushik@ibsindia.org.
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1. Introduction

While the relationship between bond and stock markets is well studied, few studies have examined the existence of nonlinearities in that relationship. Fewer yet have studied how changes in yield spread are affected by stock market behavior especially, in times of crisis. Unlike the 2008 Global Financial Crisis which rattled financial markets until the end of the Great Recession in 2010, the COVID pandemic, which erupted in early 2020, created a brief but intense negative shock in global markets. The full force of the pandemic came to light in March 2020 when the U.S. stock market fell by 13 percent. Although most equity markets rebounded shortly thereafter, the ferocity of the pandemic continued into 2021.

It is well known that bonds and stocks compete for investment funds, meaning that a faltering equity market cedes funds to bonds. With increased demand for bonds, sellers raise prices forcing yields to fall. Accordingly, bond prices rise until yields drop to a level that pairs with risk-adjusted returns in the equity market. Examples of studies that investigate the dynamics of this relationship include Rocher (2017), Moya-Martinez (2015), Amadeo (2017), Adrian, et al (2015), and Bao and Hou (2014).

Earlier, Chordia et al. (2003) show that in the short run, falling stock prices tend to drive up bond prices and reduce yields. Amer et al (2017) finds that several other factors influence this behavior. They include changes in monetary and fiscal policy, inflation, global crises, and investor sentiments. To the last point, it is obvious that the sharp drop in U.S. consumer confidence in March 2020 was chiefly instrumental in forcing the U.S. economy to a sudden recession in the second quarter of that year, amid the COVID pandemic.[1]

In a bid to contain the impact of the recession that came in its wake, many governments embarked on a series of fiscal and monetary expansions. This caused a sharp drop in short-term interest rates. By the end of the second quarter of 2020, the yield on 3-month U.S. Treasury bill fell by an unprecedented 114 basis points. Government bond yields of the same maturity in India and Brazil fell even more sharply. In India, the drop was 193 basis points while in Brazil it was more than 212 basis points. The disproportionate drop in short-term yields, relative to long-term rates, lead to a sharp rise in the slope of the yield curve.

The yield curve, also known as the term structure of interest rates, describes the relationship between maturity of bonds of the same quality and their corresponding yields. The three main types of yield curves, as summarized by Maranga et al (2018), are normal or upward sloping, inverted or downward sloping, and flat. An upward-sloping curve is one in which yields on longer-term bonds are higher, typically in response to expected economic growth. When long-term bond yields are expected to rise in the future, investors temporarily prefer shorter-term securities in hopes of moving later to long-term bonds for their higher yields. A flattening curve often portends slowing economic activity while an inverted curve is a feature that some believe foreshadows a recession. A comprehensive overview of the theories of the term structure is presented by Abbritti et al (2013).

While the onset of the pandemic forced down yields in many countries, the slope of the yield curve was more reflective of investor expectation of how deeply the pandemic might affect the global economy. To make this assessment, this study examined the degree and type of impact

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[1] "Consumer confidence tumbles in March as coronavirus cases surge," CNBC, March 31, 2020, https://www.cnbc.com/2020/03/31/us-consumer-confidence-march-2020.html. Retrieved Dec 7, 2020.

that stock returns and market volatility had on investor choices of short-term versus long-term bonds and therefore, the spread between their yields. It is hoped that the findings of this study would serve as a helpful guide for policy makers and investors alike to adopt a proactive stance especially in crisis times.

The rest of this study is summarized as follows: Section 2 presents a broad review of the literature on how financial markets respond to crises. Data and methodology are described in sections 3 while empirical results are summarized in section 4. Conclusions are presented in section 5 and it also offers some policy and investment implications.

2. Literature

A number of studies have examined causal effects of financial and geo-political shocks on financial market performance. Examples of such shocks include 1997 Asian Contagion, 1998 Russian Ruble Crisis, 9-11 (2001) terror attacks in the United States, 2008 Mumbai attacks, and 2008 Global Financial Crisis (GFC). In this section, we offer a brief survey of a subset of the literature as it relates to financial market impact over the course of some of these events.

Following the 2008 GFC, Obi et al. (2011) examine the disconnect between market and credit risks prior to the onset of the crisis. They determined that the pre-crisis rising credit risk was largely ignored by equity market investors who remained bullish ahead of the crisis. This resulted in an inverse correlation between credit risk and market risk. Antonakakis et al. (2013) explain that during such times when policy uncertainty increases, stock market returns usually turn negative with increasing volatility.

Levišauskait et al. (2014) investigate the co-movements of the stock and bond markets of each of the EU countries. They find there was no significant negative correlations between the two markets. They also find that the comovement of the two markets were more predominant during in crisis times. In a related study, Bianconi et al. (2013) examine the performance of equity and bond markets in the United States and the BRIC economies during the crisis period. They find that market volatility had more impact on Brazil and Russian bond markets than India. They also find that volatility rose for all BRIC markets in the post-crisis period.[2]

Singhania and Anchalia (2013) show that the 2008 crisis did not have as much impact on stock market volatility in Asia as it did in Europe and North America. Volatility impact was more noticeable in the larger Asian economies, including India, Japan, and China. In an event study, Mustafa et al. (2015) show that flight to quality, from stocks to bonds.

More recently, Park et al. (2017) analyze implied volatility and stock returns for the Korean market in relation to exchange rate, yield spread, and credit spread. They find that changes in exchange rate have a significant effect on volatility and stock returns. Similarly, Qiang et al. (2018) examine the linkage between implied volatility and various equity markets. In addition to the variables being cointegrated, they also find that U.S. VIX Granger-causes most of the other markets' implied volatilities. There were similar findings in Grima and Caruana (2017).

Perhaps the most significant global shock in decades was COVID-19, which began to spread in the first quarter of 2020. Beirne et al. (2020) study the economic impact of the crisis around

[2] BRIC countries are Brazil, Russia, India, and China (with South Africa, it is referred to as BRICS).

the world using a set of financial market variables. They find that emerging markets of Asia and Eastern Europe were more adversely affected by the pandemic than the advanced economies. Evidence of flight to quality from stocks to bonds, and negative correlation between the two was found by Stephanos et al. (2020).

Altig et al. (2020) assessed the economic uncertainty in the US and UK before and during COVID using several measures including VIX, policy uncertainty, Twitter chatter, and forecast disagreement about future GDP growth. The key findings are that almost all the indicators show uncertainty jumps. Oluwasegun and Johnson (2020) use BitCoin, Gold, Oil, stock returns and exchange rate to examine the linkages between commodity and financial markets during the pandemic. They find evidence that volatility spillover and causality across quintiles of the variables increased at the outset. Baker et al. (2020) investigate spikes in realized volatility and find that volatility spike during the pandemic is similar to the other major crisis periods.

In a departure from the empirical approach in the extant literature, this paper investigates how changes in bond maturity premiums are affected by equity market valuation and volatility using an asymmetric multivariate framework. Pursuant to the motivation outlined by Chordia et al. (2003), we endeavor to determine if the two markets remained cointegrated over an extended period that includes the COVID shock in 2020. Further, we proceed to identify the degree and nature of nonlinearities that exist in that relationship.

3. Data and Methodology

Weekly stock market and interest rate data were obtained from the United States, India, and Brazil. Stock market data include value-weighted stock index and the Chicago Board Options Exchange (CBOE) volatility index, VIX. Bond market data consist of 10-year and 3-month government bond yields. The slope of the yield curve was calculated as the difference between 10-year and 3-month bond yields.

Sample period for the study is March 2016 to November 2020. This period yielded 245 weekly observations. March 6, 2016 was the earliest period in which complete data on 3-month government bond yields were available for Brazil. The sample period is then subdivided into two to delineate the likely impact of COVID-19 on the financial markets. The pre-COVID period is March 2016 to December 2019 while COVID period is January 2020 to November 2020. The latter period also marks two significant events that potentially affected how financial markets might have responded to the continuing pandemic. The first was the conclusion of the very contentious U.S. presidential elections that ended in Joe Biden’s victory over the incumbent president, Donald Trump. The second was the discovery of two COVID-19 vaccines by Pfizer/BioNTech and Moderna.

Estimation model in this study is the nonlinear autoregressive distributed lag (NARDL) bounds test a’la Shin et al. (2014). In addition to preserving the many benefits of its precursor, the autoregressive distributed lag model (ARDL) model, popularized by Pesaran et al. (2001), the NARDL specification decomposes regressors into their positive and negative shocks to identify asymmetries in relationships where they exist. The functional form of the three-variable model for each of the country’s financial markets is expressed as

$$YC_{it} = f(R_{it}, VIX_{it}), \qquad \text{-------} \quad (1)$$

where YC is slope of the yield curve, measured as the difference between yields on 10-year and 3-month government bonds; R is the rate of return on a value-weighted stock index; and VIX is the CBOE implied volatility index. All variables are in their logarithmic form. The NARDL model represents the asymmetric error correction model as follows:

$$\Delta YC_t = \alpha_0 + \sum_{i=1}^{p} \alpha_1 \Delta YC_{t-i} + \sum_{i=0}^{p} \alpha_2 \Delta R_{t-i}^{+} + \sum_{i=0}^{p} \alpha_3 \Delta R_{t-i}^{-} + \sum_{i=0}^{p} \alpha_4 \Delta VIX_{t-i}^{+} + \sum_{i=0}^{p} \alpha_5 \Delta VIX_{t-i}^{-} \quad \text{-------} \quad (2)$$
$$+\rho YC_{t-1} + \varphi_1^{+} R_{t-1}^{+} + \varphi_1^{-} R_{t-1}^{-} + \varphi_2^{+} VIX_{t-1}^{+} + \varphi_2^{-} VIX_{t-1}^{-} + \mu_t$$

In Equation (2), α_i denote short-run coefficients, while φ_I are the long-run coefficients. Regressors are decomposed into their positive and negative partial cumulative sums for increases (positive changes) and decreases (negative changes), as follows:

$$x_t^{+} = \sum_{j=1}^{t} \Delta x_j^{+} = \sum_{j=1}^{t} \max(\Delta x_j, 0); \qquad x_t^{-} = \sum_{j=1}^{t} \Delta x_j^{-} = \sum_{j=1}^{t} \min(\Delta x_j, 0) \quad \text{-------} \quad (3)$$

where x_t represents R_{it} and VIX_{it}. To test the existence of asymmetric long-run cointegration, Shin et al. (2014) propose the bounds test, which is a joint test of all the lagged levels of the regressors. Two tests of significance that serve this purpose are the t-statistic of Banerjee et al. (1998) and the F-statistic of Pesaran et al. (2001). The t-statistic tests the hypothesis $\varphi = 0$ against the alternative hypothesis $\varphi < 0$. The F-statistic tests the null hypothesis, $\rho = \varphi_1^{+} = \varphi_1^{-} = \varphi_2^{+} = \varphi_2^{-} = 0$. If we reject the null hypothesis of no cointegration, we conclude that a long-run relationship exists among the variables.

Long-term asymmetric coefficients are estimated as $L_{M1+} = \frac{-\varphi_1^{+}}{\rho}$ and $L_{M1-} = \frac{-\varphi_1^{-}}{\rho}$.

Using Wald test, the following null hypotheses for long run and short run asymmetric relationships are tested:

Long-run H_0: $\frac{-\varphi_i^{+}}{\rho} = \frac{-\varphi_i^{-}}{\rho}$

Short-run H_0: $\sum_{i=0}^{q} \delta_i^{+} = \sum_{i=0}^{q} \delta_i^{-}$

A rejection of any of the null hypotheses is evidence the impact of x on y is asymmetric, suggesting that the magnitude of changes in Y when the independent variable increases is not the same as when it decreases.

4. Results

Pre-post descriptive statistics of the variables are first presented. Following that, we show results of unit root tests and after, results of asymmetric cointegration tests. Finally, results of causality tests between slope of the yield curve and the two regressors are discussed.

Pre-post comparative statistics are presented in Table I. Panel A shows the average yield spread for U.S. was actually greater in pre-COVID than during COVID. The reverse is the case for India and Brazil. Differences in pre-post spread were statistically significant. In Panel B of Table I, we find that U.S. and Brazil experienced greater variability in the spread prior to the pandemic. Spread variability for India was greater during the pandemic, a sign perhaps that investors were still unsure of how best to allocate their funds across the two maturity sectors. As with the mean spread, changes in spread variability were also statistically significant.

Table I. Comparative Statistics: Slope of Yield Curve +

Panel A. Mean	**Before**	**COVID-19**	**t-statistic**	**p-value**
USA	0.9414	0.4880	8.0377***	0.0000
India	0.8775	2.2852	15.4055***	0.0000
Brazil	1.4365	4.2433	12.6326***	0.0000
Panel B. Variance	**Before**	**COVID-19**	**F-statistic**	**p-value**
USA	0.3908	0.0553	7.0711***	0.0000
India	0.1476	0.3425	2.3207***	0.0000
Brazil	5.3688	1.0135	5.2971***	0.0000

+ Slope = Yield spread between 10-year and 3-month government bonds
Pre-data period: March 6, 2016 – December 29, 2019. COVID-10 period: January 5, 2020 – November 8, 2020.
*** Significant at $\alpha = 0.01$, ** Significant at $\alpha = 0.05$, * Significant at $\alpha = 0.10$

Table II shows results of the descriptive statistics. With the exception of stock indices which are measured as logarithmic returns, all other variables are expressed at level. The mean yield spread is positive in both pre-COVID and COVID periods, although the spread is distinctly higher for India and Brazil in the latter period. These results supplement the results of test of significance shown in Table I. For the most part, the slope has negative kurtosis or platykurtic, meaning that the distribution is flatter than that of the normal distribution. The slope is much less platykurtic in the COVID period, which supports the view of rising uncertainty in the bond market. Finally, the distributions are mostly negatively skewed, suggesting that the mass of the distribution is concentrated on the right. Negative skewness is more pronounced in the COVID period. The combined effects of a platykurtic distribution and negative skew suggest that the slope is unlikely from a normal distribution.

Table II: Descriptive Statistics+

PANEL A. PRE COVID-19 PERIOD ++

	USA Slope	**India Slope**	**Brazil Slope**	**USA VIX**	**India VIX**	**Brazil VIX**	**USA Index**	**India Index**	**Brazil Index**
Mean	0.94	0.88	1.44	14.18	14.82	33.63	0.00	0.00	0.00
Std. dev.	0.63	0.38	2.32	3.77	2.73	6.67	0.02	0.02	0.02
Kurtosis	-0.76	-0.89	-0.99	3.14	3.79	1.90	3.35	1.08	0.24
Skewness	-0.44	0.06	-0.22	1.53	1.32	1.39	-0.98	-0.20	-0.55
Sample size	200	200	200	200	200	200	200	200	200

PANEL B. COVID-19 PERIOD +++

	USA SLOPE	INDIA SLOPE	BRAZIL SLOPE	USA VIX	India VIX	Brazil VIX	USA Index	India Index	Brazil Index
Mean	0.49	2.29	4.24	29.90	27.89	52.27	0.00	0.00	0.00
Std. dev.	0.24	0.59	1.01	12.11	13.37	21.91	0.05	0.04	0.06
Kurtosis	1.06	-0.78	-0.50	2.24	2.57	3.98	3.42	2.04	3.39
Skewness	-1.21	-0.84	-0.78	1.31	1.65	1.64	-1.02	-0.46	-1.23
Sample size	45	45	45	45	45	45	45	45	45

+ All variables expressed at level except for stock indices which are expressed as logarithmic returns.
++ March 6, 2016 – December 29, 2019
+++ January 5, 2020 – November 8, 2020

Unit root test results are summarized in Table III. Only the slope of the yield curve is stationary after first differencing. The rest are stationary at level. Inclusion of a mix of I(0) and I(1) time series variables in the error correction framework is what makes the use of autoregressive distributed lag or its nonlinear equivalent appropriate.

Table III. Unit Root Test Results

	Levels		1st Difference	
	t-statistic	p-value	t-statistic	p-value
Panel A. Slope				
U.S.A.	-2.5058	0.1150	-20.9092***	0.0000
India	0.3377	0.9799	-15.2113***	0.0000
Brazil	1.1101	0.9975	-20.7437***	0.0000
Panel B. Equity index				
U.S.A.	-19.0279***	0.0000		
India	-16.5731***	0.0000		
Brazil	-10.3530***	0.0000		
Panel C. VIX				
U.S.A.	-4.1960***	0.0008		
India	-3.3307**	0.0144		
Brazil	-3.5069***	0.0086		

Null hypothesis: Series has unit root (non-stationary). Constant, no trend.
*** Significant at $\alpha = 0.01$, ** Significant at $\alpha = 0.05$, * Significant at $\alpha = 0.10$
Slope =Yield spread between 10-year and 3-month government bonds. Equity index= S&P 500 (USA), S&P BSE 500 (India), and Bovespa (Brazil). VIX = Chicago Board Options Exchange volatility index. All variables in natural logarithm.

Results of the multivariate asymmetric cointegration tests are presented in Table IV. Three asymmetric error correction models were estimated, one for each of the three economies. With slope as target variable, all the models were found to be cointegrated at least at the 0.05 level of significance. In all cases, the null hypothesis of no cointegration is rejected, because the F-statistic is greater than the upper bound I(1) critical value established by Pesaran et al (2001).

Table IV. NARDL Cointegration Test Results

Target variable: Slope +						
Panel A: USA						
	F	**Sig**	**I(0)**	**I(1)**	**ECT_{t-1}**	**p-value**
	15.05**	0.05	2.86	4.01	-0.0928	0.0000
Panel B: India						
	F	**Sig**	**I(0)**	**I(1)**	**ECT_{t-1}**	**p-value**
	4.25**	0.05	2.86	4.01	-0.0537	0.0000
Panel C: Brazil						
	F	**Sig**	**I(0)**	**I(1)**	**ECT_{t-1}**	**p-value**
	16.52**	0.05	2.86	4.01	-0.0037	0.0000

** Significant at $\alpha = 0.05$.
+ Slope of yield curve = Yield spread between 10-year and 3-month government bonds.
++ Regressors: Equity index and CBOE volatility index.

The error correction mechanism allows us to determine the speed of adjustment to long-run equilibrium. This information is provided in the last two columns of Table IV. The coefficient of the error-correction term (ECT) is statistically significant with the correct (negative) sign. For the U.S., about 0.09 percent of departures from equilibrium are corrected each period. The values for India and Brazil are 0.05 percent and 0.004, respectively. One can infer that U.S. bond market is able to reattain equilibrium at a faster rate than the other markets.

Results of long-run levels asymmetry are presented in Table V. We find that both positive and negative shocks to stock index have a negative causal effect on the slope. This means that movements in the stock markets, up or down, have opposite effects on the slope. Thus, in the long run, bear markets cause rising maturity premiums, a confirmation of the expectations theory of term structure of interest rates. Both positive and negative changes in the volatility index, VIX, have a direct impact on the slope. Positive shocks lead to rising yield curve while negative shocks lead to a declining slope.

Table V. NARDL Long Run Asymmetric Levels Result

Target variable: Slope +			
Panel A: USA			
Regressor	**Coefficient**	**t-Stat**	**p-value**
USINDEX_POS	-86.9895**	-2.5143	0.0125
USINDEX_NEG	-90.9741**	-2.5830	0.0103
Wald test: F = 14.81***			
USVIX_POS	0.3217	1.2458	0.2138
USVIX_NEG	1.0849*	1.9648	0.0504
Wald test: F = 20.33***			

Panel B: India			
Regressor	**Coefficient**	**t-Stat**	**p-value**
ININDEX_POS	-7.9784*	-1.9062	0.0576
ININDEX_NEG	-8.5396**	-1.9744	0.0493
Wald test: F = 1.45			
INVIX_POS	0.2960**	2.3560	0.0192
INVIX_NEG	0.4135***	2.6124	0.0095
Wald test: F = 0.92			
Panel C: Brazil			
Regressor	**Coefficient**	**t-Stat**	**p-value**
BRINDEX_POS	-153.3599	-0.2558	0.7984
BRINDEX_NEG	-189.229	-0.2557	0.7984
BRVIX_POS	-7.8199	-0.2409	0.8099
BRVIX_NEG	5.8698	0.2650	0.7913

*** Significant at $\alpha = 0.01$, ** Significant at $\alpha = 0.05$, * Significant at $\alpha = 0.10$
+ Slope = Yield spread between 10-year and 3-month government bonds.
++ Regressors: Equity index and VIX. All variables in natural logarithm.

Wald asymmetric long-run test null hypothesis: $\frac{-\varphi_i^+}{\rho} = \frac{-\varphi_i^-}{\rho}$

Asymmetric models allow us to measure differences in the degree of causal effect due to positive and negative changes in the regressor. The null hypothesis is that positive and negative shocks in the regressor exert the same magnitude of impact on the dependent variable. By rejecting the null hypothesis, we conclude that the relationship between the dependent variable and the regressor is nonlinear. This asymmetric inquiry is performed using Wald test. Results presented in Table V show evidence of long-run asymmetry but only in the case of the United States. For both the stock and volatility indices, F statistic is significant at the 0.01 level. This implies that taking nonlinearity into account is important when studying the relationship between changes in the slope of the yield curve and stock valuation and also, between slope and volatility index. There is no evidence of asymmetries for the two BRIC countries. All of this point to the fact that while these three large economies have a shared experience in crisis times, investor sentiments are not similar or at least not of the same magnitude.

Short-Run Asymmetries

Results of short-run asymmetric test are summarized in Table VI. In Panel A, which shows results for U.S., we find evidence of short-run asymmetry between slope and stock index and also between slope and volatility index. Panels B and C show results for India and Brazil. For these two countries, there is evidence of short-run asymmetry but only for volatility index. Tests of short-run asymmetry are based on the F statistic from Wald test.

Short-run effects of market volatility shows that positive shocks lead to a flattening slope while negative shocks cause it to rise. Unlike the U.S. and India, only positive shocks to volatility in Brazil affect the slope. Direction of impact is positive. This finding suggests that for this middle-income economy with developing market infrastructure, risk appears to be more impactful in asset allocation than return.

Table VI. NARDL Short Run Asymmetric Result

Target variable: Slope +			
Panel A: USA			
Regressor	**Coefficient**	**t-Stat**	**p-value**
D(USINDEX_POS)	-2.6737***	-3.4544	0.0007
D(USINDEX_NEG)	-4.4575***	-3.9363	0.0001
Wald test: F = 18.28***			
D(USVIX_POS)	-0.5717***	-3.9095	0.0001
D(USVIX_POS(-1))	-0.3213**	-2.2439	0.0258
D(USVIX_NEG(-1))	-0.5104***	-3.6603	0.0003
Wald test: F = 15.05***			
Panel B: India			
D(INVIX_POS)	-0.0414	-1.4470	0.1493
D(INVIX_POS(-1))	-0.0673**	-2.3235	0.0210
D(INVIX_NEG)	-0.0712**	-2.3579	0.0192
Wald test: F = 5.61**			
Panel C: Brazil			
Regressor	**Coefficient**	**t-Stat**	**p-value**
D(BRVIX_POS)	0.0616*	1.8525	0.0652
D(BRVIX_POS(-1))	0.0779**	2.1960	0.0291
D(BRVIX_POS(-2))	0.0600*	1.7481	0.0818
Wald test: F = 6.14***			

*** Significant at $\alpha = 0.01$, ** Significant at $\alpha = 0.05$, * Significant at $\alpha = 0.10$
+ Slope = Yield spread between 10-year and 3-month government bonds.
++ Regressors: Equity index and VIX. All variables in natural logarithm.

Wald asymmetric test null hypothesis: $\sum_{i=0}^{q} \delta_i^+ = \sum_{i=0}^{q} \delta_i^-$

Test diagnostics for this study include serial correlation, heteroscedasticity, and normality. The null hypotheses of no serial correlation and homoscedasticity could not be rejected. Also, the Jacque-Berra statistic could not reject the hypothesis of normal distribution. Test of model stability based on CUSUM test indicates the model is largely dynamically stable. For brevity, results of these diagnostic tests are not included.

5. Conclusion and Policy Implications

This study examined how the pricing of fixed income securities in the top three large economies at different levels of economic development was affected by the equity market. The countries are U.S., India, and Brazil. The estimation framework is the newly developed nonlinear autoregressive distributed lag (NARDL) model. The model examined the effects of stock returns and implied volatility on the slope of the yield curve. Slope is measured as the yield difference between 10-year and 3-month government bonds.

Nonlinear cointegration tests confirm the existence of a long-run relationship. For the U.S. and India, both negative and positive shocks in stock returns have a reverse effect on bond maturity premiums. In other words, a bull market causes a flattening yield curve while a bear market steepens it. These effects are asymmetric, especially for the U.S. where a negative shock in stock returns tends to have a greater impact than a positive shock.

Short-run causality tests also revealed that positive and negative shocks in stock returns have an inverse effect on the slope of the yield curve for U.S. and India. There is no evidence of short-run impact for Brazil. For U.S. and India, positive and negative shocks in implied volatility have a reverse effect on the slope, which suggests that when uncertainty declines, it leads to an expansion in maturity premiums. The impact of volatility is diminutive in the case of Brazil.

Overall, this study finds that the secular relationship between stock and bond markets was sustained through the course of pandemic in 2020. However, this evidence is only true for U.S. and India. The finding that the two markets maintained a consistent albeit nonlinear relationship, in spite of the severity of the pandemic, attests to the resilience of these economies.

There is perhaps one important policy implication and one essential investor proposition from this study. First, the disproportionate impact of pandemic on the hospitality and tourism industry required targeted government assistance for that sector. By the end of the second quarter of 2020, it became obvious that the most vulnerable businesses were airlines, hotels, restaurants and such. This was reflected in the sharp decline in the Dow Jones Travel & Tourism Index, which fell by almost 50 percent between February and March 2020. In contrast, the broad-based U.S equity index fell by only 19 percent. Equity market declines in India and Brazil during the same period were 28 percent and 33 percent, respectively.

The second implication stems from the asymmetric relationship between the slope of the yield curve and the stock market. The study finds that stock market declines cause a greater rise in the slope of the yield curve than a bull market would cause a fall in the slope. This suggests that the gap between long-term and short-term interest rates is much wider in a bear market. Because an upsloping yield curve suggests an expectation of a future rise in interest rates, it would be prudent for investors to temporarily place their funds in short-term securities. Later, when interest rates rise, forcing bond prices to drop, investors can then reallocate funds into higher yielding bonds.

The vulnerability of hospitality and tourism stocks in times of crisis makes them particularly attractive at such times. Long-term investors could take advantage of depressed stock prices by allocating a significant portion of their long-term funds into this sector in addition to a well-diversified stock portfolio.

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