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Article abstract

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Asymmetric Volatility in the Nepalese Stock Market[1]

by

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This paper investigates the asymmetric volatility behavior of the Nepalese stock market including spillover effects from the US and Indian equity markets. I modeled asymmetric volatility within a generalized autoregressive conditional heteroskdasticy framework using comprehensive data for the Nepal stock market index. The results reveal a very different asymmetry compared to the results in other international equity markets: positive shocks increase volatility by more than negative shocks. The results further suggest that uninformed investors play a significant role in the Nepalese stock market. The spillover effect from the Indian stock market to the Nepalese stock market is negative. Overall, I conclude that a "fear of missing out" (FOMO) of noise traders as well as the deployment of pump and dump schemes are inherent features of the Nepalese stock market. The findings are very useful to policy makers and investors alike.

1. Introduction

The Nepalese stock market is relatively young and small, and has remained highly volatile. K.C. (2010) argues that the market is largely dominated by speculators, therefore making the market more fragile. While speculators help to make markets more liquid, they may increase market fragility and market panic which in turn dry up investors' money. Market volatility is also driven by the amount of information investors have. Well-informed investors tend to evaluate stock fundamentals when making decisions while uninformed investors may rely on other factors and may exhibit herding (Hellwig, 1980; Wang, 1993). The trading of informed and uninformed investors leaves different traces in the stock return process. As postulated in Campbell et al. (1993), informed trades will result in zero autocorrelation in stock returns whereas uninformed trades will result in non-zero autocorrelation in stock returns. Avramov et al. (2006) argue that price changes due to uninformed investors will increase volatility by more than price changes due to informed investors. If the market is dominated by less informed speculators, then the market will be very volatile and very fragile. In this paper, I propose to exploit this idea and investigate who trades stocks on the Nepalese stock market depending on the market situation.

The literature suggests that stock market volatility responds differently to positive and negative shocks in stock returns (Bekaert & Wu, 2000; Christensen et al., 2015; Horpestad et al., 2019). Such asymmetric responses to return shocks are known as asymmetric volatility and attributed to the financial leverage effect (Black, 1976; Christie, 1982), the volatility feedback effect (Pindyck, 1984; French et al., 1987; Campbell & Hentschel, 1992), and investors' behavior (French & Roll, 1986; Avramov et al., 2006). The leverage effect hypothesis states that a decrease in the price of a stock increases financial leverage, which makes the stock riskier and increases its volatility. The volatility feedback effect hypothesis argues that an increase in market volatility requires a higher risk premium, leading to a decline in stock price. Behavioral finance theory argues that asymmetric volatility arises due to the biases of investors under uncertainty.

While the leverage effect hypothesis and time-varying risk-premia hypothesis may hold in lower frequency data such as quarterly or annual data, they are unlikely to be manifested at a daily frequency (Avramov et al., 2006). Daily changes in leverage could be transitory and economically very small. In addition, expected returns may change with the business cycle and this variation, if present, is unlikely to be observable at higher frequencies (Avramov et al., 2006). Avramov et al. (2006) argue that trading activity is a main source of the asymmetric volatility phenomenon at a daily frequency. French and Roll (1986) argue that trading causes volatility. Thus, the asymmetric volatility phenomenon could be a result of the trading process. In this paper, using daily data, I apply behavior theories to explain the asymmetric volatility phenomenon in the Nepalese stock market. The analysis of the impact of positive and negative return shocks on volatility helps to characterize the behaviors of investors. As I only have the aggregate market index price data for Nepal, I take the approach of Baur and Dimpfl (2018) to characterize the types of investors and their dominance in the market (trading activity) as postulated in Avramov et al. (2006). To this end, I use the asymmetric GARCH models of Nelson (1991) and Glosten et al. (1993).

The integration of equity markets at the regional level and at the global level has been increasing over the last few decades. Understanding the behavior and sources of volatility is also important for international hedging strategies, and for the development of regulatory proposals for international investment. The literature in international finance suggests that information spillover is a general tendency in the international equity markets (King & Wadhwani, 1990; Dungey & Gajurel, 2014, 2015). This study also intends to examine the fundamental forces driving return volatility in the Nepalese stock market. I focus on to what extent volatility in the Nepalese stock market is influenced by international stock markets, specifically the US equity market and the Indian stock market. The US market represents an international benchmark or a global factor. India is the largest trading partner of Nepal and the Indian equity market is one of the largest emerging markets. As a result, it is expected that there is information spillover from the US and Indian stock markets to the Nepalese stock market. In addition, including these two markets in the study allow me to compare and contrast asymmetric volatility effects across different types of equity markets.

This paper is primarily motivated by three factors. First, most studies that examine asymmetric volatility in international stock markets focus on the developed and large emerging markets. There is a lack of study in the Nepalese context. Second, it is of utmost importance to identify the return process and to distinguish the influences of informed and uniformed traders on the return process. Thapa and Nepal (2015) report that the financial literacy rate is very low in Nepal. In this context, safeguarding the interests of general investors is very important from a regulatory perspective. Unfolding return-volatility dynamics provides meaningful insights for investors and regulators alike. Finally, my model encapsulates international spillover effects in both first order and second order moments while assessing asymmetric volatility behavior.

This paper contributes to a long line of literature in stock market volatility. I use comprehensive daily data from the Nepalese stock market. The data collection for the Nepalese stock market is done manually, which is time-consuming and requires attention to detail and caution in extracting the data from the Security Board of Nepal and the Nepal Stock Exchange archives. I am the first to examine the mean and volatility spillovers from the global and regional markets to the Nepalese stock market, and to characterize the inverted asymmetric response in the Nepalese context.

The remainder of the paper is organized as follows: Section 2 reviews the relevant literature in asymmetric volatility including an overview of the Nepalese stock market; Section 3 discusses the data and methodology; Section 4 provides the results and discussion; and Section 5 concludes the paper.

2. Literature Review

2.1. An Overview of the Nepalese Stock Market

Nepal has a short history of capital market development with the establishment of the Securities Marketing Center (SMC) in 1976. In 1984, the Securities Exchange Act was promulgated and the SMC was converted into the Securities Exchange Center (SEC). In addition to facilitating trade, SEC also oversaw the roles of broker, and underwriter and issue manager of shares and government securities. In between 1984 and 1990 about forty two companies, mostly state-owned, were listed in the SEC. Adapting to economic liberalization and privatization policies in late 1980s, the government changed the structure of the SEC, splitting it into the Securities Board of Nepal (SEBON) and the Nepal Stock Exchange Limited (NEPSE) in 1993. Since then these two organizations have operated as the main constituents of the securities market in Nepal. As a regulatory authority, SEBON is responsible for the development of a competitive capital market and maintains its credibility, fairness, efficiency, transparency, and responsiveness under the Securities Related Act of 2007 (Regmi, 2012; Thapa & Gautam, 2016). NEPSE was established with the objective of imparting free marketability and liquidity to the government and corporate securities by facilitating transactions in its trading platform through members and market intermediaries such as brokers and market makers (Thapa & Gautam, 2016). NEPSE implemented automated screen-based market trading in 2007. As of September 2019, there are 243 stocks (companies) listed in the exchange with a total market capitalization of about Rs.1.5 trillion - US $13.1 billion. Over the last twenty-five years, the NEPSE index increased from 196.17 in July 1995 to 1272.5 in July 2019 with many ups and downs and has remained highly volatile.

2.2. Explaining Volatility Asymmetry

The empirical literature largely finds that stock market volatility responds more to negative shocks ("bad news") than to positive shocks ("good news"). However, why such asymmetry exists has remained a puzzle. There are three main explanations. The first one is the "leverage effect hypothesis" or leverage hypothesis which was introduced by Black (1976) and advanced by Christie (1982). According to this hypothesis, a firm's stock volatility changes due to changes in its financial and operating leverages. Negative shocks in stock returns reduce the value of equity and increase financial leverage making the stock risker and increasing the future expected volatility. Schwert (1989) argues that operating leverage negatively affects stock volatility and that the relationship is more pronounced during recessions. Thus, both operating and financial leverages cause firms to be riskier and to have higher volatility when stock prices decline.

The second explanation, often referred to as the "feedback effect hypothesis" or "time-varying risk premium" hypothesis, is postulated by Poterba and Summers (1986) and Campbell et al. (1993). This hypothesis states that negative change in expected returns tends to be intensified whereas a positive change in expected returns tends to be dampened and these effects generate the asymmetric volatility phenomenon (French et al. (1987); Campbell & Hentschel (1992)). An anticipated increase in volatility raises the required return of return on equity, leading to an immediate stock price decline. Bekaert and Wu (2000) argue that a reason for the asymmetry in aggregate market returns is that firm returns are more correlated in down markets. The feedback effect hypothesis assumes that the actual realized stock return influences investor perceptions of future volatility and that this perception is fed back into the contemporaneous dynamic return process. Thus, the causality between increasing volatility and negative returns is opposite to that of the leverage effect hypothesis.

In addition to the leverage effect and the feedback effect hypotheses which are fundamentals based explanations, a growing number of studies provide behavioral explanations to asymmetric volatility (Hellwig, 1980; Wang, 1994; Froot et al., 1992; Jones et al., 1994; Chan & Fong, 2000; Avramov et al., 2006; Dennis et al., 2006; Shefrin, 2008; Hibbert et al., 2008; Talpsepp & Rieger, 2010; Andrei & Hasler, 2015). Behavioral finance theory postulates that the heterogeneous behavioral traits of market participants such as representativeness, affect emotion or extrapolation biases give rise to a negative (positive) correlation between anticipated risk and expected return hence leading to an increase (decrease) in expected volatility (Shefrin, 2008). Investors may use rules of thumb and extrapolation from past events while making investment decisions. De Bondt (1993) states that non-experts are optimistic in bull markets and pessimistic in bear markets. Similarly, uninformed or less informed traders may exhibit herding which could be more pronounced during stressful market conditions as they are likely to reduce the stress of expected investment risk. The uninformed traders who herd when prices decline and the informed traders who reduce volatility when prices increase are a main cause of asymmetric volatility (Avramov et al., 2006). Talpsepp and Rieger (2010) argue that investor sentiment is a driving force of asymmetric volatility.

The empirical results on the leverage effect and feedback effect hypotheses are mixed and inconclusive. While Black (1976); Christie (1982); Bollerslev et al. (2006); Ederington and Guan (2010) find a negative leverage effect, Choi and Richardson (2016) find a positive leverage effect. Bekaert and Wu (2000) reject the pure leverage model of Christie (1982). Some recent studies such as Daouk and Ng (2011), and Ericsson et al. (2016) provide strong evidence for the leverage effect. However, Hens and Steude (2009) and Hasanhodzic and Lo (2019) show that volatility asymmetry exists even for assets with no leverage. Regarding the evidence on the feedback effect hypothesis, some, for example, French et al. (1987); Campbell and Hentschel (1992); Bekaert and Wu (2000); Wu (2001), and Ghysels et al. (2005) find support for a positive relationship whereas others, e.g., Breen et al. (1989); Glosten et al. (1993); Bollerslev et al. (2006), and Lettau and Ludvigson (2010) obtain negative or insignificant results.

There are also a growing number of empirical studies providing evidence in favor of behavioral explanations. Avramov et al. (2006) show that herding can have effects on volatility asymmetry. Talpsepp and Rieger (2010) find that volatility asymmetry is positively related to analyst coverage and media penetration, and higher participation of private investors. Dzielinski et al. (2011) find that the number of individual investors in the market can have an effect on volatility asymmetry. Hibbert et al. (2008) confirms that the asymmetric relationship arises more from agents' heuristics and emotional biases than from the fundamentals based hypotheses. Dzellinksi et al. (2018) show that the asymmetry of stock return volatility is positively related to investor attention and differences of opinion. Talukdar et al. (2017), using high-frequency tick data, also find that behavioral theories explain the return–volatility nexus better than fundamental theories.

While most of the existing studies examine the asymmetric return-volatility relationship in the US equity market, recent studies provide supports for either one or more hypotheses from international equity markets. Bekaert and Wu (2000) examine asymmetric volatility in the Japanese equity market and conclude that volatility feedback is the dominant cause of the asymmetry for the Japanese stock market. Yeh and Lee (2000) examine volatility asymmetry in the Hong Kong, Taiwan, Shanghai and Shenzhen stock markets and find that positive shocks increase volatility more than negative shocks in the Shanghai and Shenzhen stock markets. Similarly, Jayasuriya et al. (2009) find that mature markets exhibit larger magnitudes of asymmetric volatility than emerging ones, and the asymmetry is greater during the volatile market periods. However, the authors do not distinguish the direction of the asymmetry. Christensen et al. (2015) examine the leverage effect in the stock markets of G7 and BRIC countries and find evidence of the leverage effect on all of the countries except Italy, and the leverage effect is more pronounced during periods of crisis. Similarly, Bekiros et al. (2017) investigate the asymmetric relationship between returns & implied volatility for 20 developed and emerging markets. Their results show that the US market displays the highest reaction to price falls, Asian markets present the lowest sensitivity to volatility expectations, and Europe is characterized by a homogeneous response both in terms of direction and impact. They conclude that behavioral theories explain the asymmetric volatility effects better than the classical leverage and feedback effect hypotheses. Horpestad et al. (2019) examine asymmetric volatility in equity markets around the world (for 19 country-specific equity indices)[3] and confirm that all the stock market indices in the sample show the asymmetric volatility effect, although the effect is stronger for developed markets.

There is a scarcity of systematic studies in the Nepalese context. G.C. (2008) is perhaps the first to examine volatility in the Nepalese stock market using data for the period of 2003–2009. While the results from asymmetric GARCH models show the presence of an asymmetric volatility effect, the author misinterprets the results and wrongly concludes that there is "no significant asymmetry." Thapa and Gautam (2016) examine asymmetric volatility using data for the period of 1997–2012 and report asymmetric volatility effects (actually an inverted asymmetric effect) and yet misinterpret the findings. The misinterpretation of asymmetric results in G.C. (2008) and Thapa and Gautam (2016) could be due to synonymous use of the terms *leverage effect* and *asymmetric volatility*. Chang and McAleer (2017) point out that the conditions for asymmetry in GARCH models, in particular EGARCH, have been ignored in the literature, or that researchers have concentrated on the incorrect conditions, and hence give misleading interpretations; see also Charles and Darne (2019). In this paper, using data for the last quarter century, I characterize the asymmetric volatility in the Nepalese stock market.

3. Empirical Framework

3.1. Modeling Asymmetric Volatility

Since the seminal financial time series model introduced by Engle (1982) and generalized by Bollerslev (1986), the generalized autoregressive conditional heteroskedasticity (GARCH) models have remained a dominant econometric framework for volatility modeling. In a conventional GARCH(1,1) model, the mean equation can be expressed as:

$$r_t = \mu + \varepsilon_t; \;\; \varepsilon_t \sim i.i.d.(0, \sigma_t) \tag{1}$$

where r_t represents the stock market return at time t. μ is the unconditional mean of returns, and ε_t is the error term which follows the time-varying volatility process with conditional volatility σ_t. To detect serial correlation as suggested by Avramov et al. (2006) in the presence of noise traders, I use an autoregressive model of order 1 (AR(1)) for the return process

$$r_t = \mu + \theta r_{t-1} + \varepsilon_t, \tag{2}$$

where parameter θ captures the predictive power of lagged returns in the mean equation. If the financial market is efficient and dominated by informed investors, I expect that $\theta = 0$.

The conditional variance equation in GARCH(1,1) can be written as:

$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2 \tag{3}$$

where non-negativity constraints are imposed on parameters ω, α, and β with an additional constraint $\alpha + \beta < 1$ to ensure that the GARCH process is non-explosive and conditional variance is positive. The Eq. (3) implies that the variance at time t depends on shocks on lag returns and its own lag. I can extend the GARCH (p, q) model by accommodating p number of lags for return shocks and q number of lags for the autoregressive term of conditional variance. Since my goal is not to compare various models and not to forecast but to investigate the asymmetric volatility effect, I choose a GARCH(1,1) process. I argue that GARCH(1,1) is usually sufficient to capture the volatility clustering properties of financial data.

The basic GARCH model specification in Eq. (3) includes squared residuals and the signs of the return shocks have no effect on conditional volatility. However, a stylized fact of financial volatility is that negative shocks tends to have a different impact on volatility than positive shocks. In general, volatility tends to be higher in a down market than in an up market. There are several ways to incorporate an asymmetric effect into a GARCH model. Two well-established asymmetric models are the exponential GARCH (EGARCH) model of Nelson (1991) and the threshold GARCH (TGARCH) model of Glosten et al. (1993).

In the basic EGARCH model of , the conditional variance equation can be specified as follows:

$$log(\sigma_t^2) = \omega + \alpha|z_{t-1}| + \gamma z_{t-1} + \beta log(\sigma_{t-1}^2) \tag{4}$$

where $z_{t-1} = \varepsilon_{t-1}/\sigma_{t-1}$. Zivot (2009) mentions that when the shock, ε_{t-1}, is positive or there is "good news", the total effect of the shock is $(1+\gamma)|\varepsilon_{t-1}|$ and when ε_{t-1} is negative or there is "bad news", the total effect of the shock is $(1-\gamma)|\varepsilon_{t-1}|$. If we anticipate that negative shocks can have a larger impact on volatility, we would expect γ to be negative. An advantage of EGARCH is that it does not require non-negativity constraints on parameters.

Similarly, in the threshold GARCH model of , the conditional variance takes the following form:

$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \gamma\varepsilon_{t-1}^2 I(\varepsilon_{t-1} < 0) + \beta\sigma_{t-1}^2 \tag{5}$$

where $I(.)$ is an indicator function that takes value 1 if $\varepsilon_{t-1} < 0$, and 0 otherwise. The parameter γ captures the asymmetric effect of return shocks on conditional volatility. More specifically, the parameter α captures the effect of positive return shocks whereas the sum of α and γ captures the effect of negative shocks. As suggested in the literature we expect that $\gamma > 0$, i.e., negative shocks increase volatility more than positive shocks. Apart from the constraints defined for Eq. (3), the TGARCH model has to satisfy a condition: $1 - \alpha - \beta - 0.5\gamma < 0$.

To identify how the volatility of the Nepalese stock market reacts to positive or negative shocks, we implement both the EGARCH and TGARCH models specified above. We also model asymmetric volatility for the US stock market and the Indian stock market to provide some comparative perspectives.

3.2. Measuring International Spillover Effects

The literature in international finance suggests that in globalized economies, domestic financial markets are influenced by international financial markets, known as the spillover effect. To be specific, I capture the spillover effects in both mean and variance equations from two major markets - the US stock market, and the Indian stock market.

While modeling for the Indian stock market I include US spillover effects as follows:

Mean equation:

$$r_{IN,t} = \mu_{IN} + \theta_{IN} r_{IN,t-1} + \delta_{IN} r_{US,t-1} + \varepsilon_{IN,t} \tag{6}$$

Variance equation - EGARCH:

$$\begin{aligned} log(\sigma_{IN,t}^2) \quad = \quad & \omega_{IN} + \alpha_{IN}|z_{IN,t-1}| + \gamma_{IN} z_{IN,t-1} + \beta_{IN} log(\sigma_{IN,t-1}^2) \\ & +\phi_{US} log(\hat{\sigma}_{US,t-1}^2); z_{IN,t-1} = \frac{\varepsilon_{IN,t-1}}{\sigma_{IN,t-1}} \end{aligned} \tag{7}$$

Variance equation - TGARCH:

$$\sigma_{IN,t}^2 = \omega_{IN} + \alpha_{IN}\varepsilon_{t-1}^2 + \gamma_{IN}\varepsilon_{t-1}^2 I(\varepsilon_{t-1} < 0) + \beta_{IN}\sigma_{t-1}^2 + \phi_{US}\hat{\sigma}_{US,t-1}^2 \tag{8}$$

In Eqs. (6), (7), and (8), I am assuming that the spillover effect is unidirectional, that is, from the US to India, not the other way around. Due to geographical differences, I capture the lagged spillover effect from the US to India.

Similarly, while modeling volatility for Nepal, I capture spillover effects from the US and Indian markets in mean and variance equations. The equations take the following forms:

Mean equation:

$$r_{NP,t} = \mu_{NP} + \theta_{NP} r_{NP,t-1} + \delta_{US} r_{US,t-1} + \delta_{IN} r_{IN,t} + \varepsilon_{NP,t} \tag{9}$$

Variance equation - EGARCH:

$$\begin{aligned} log(\sigma^2_{NP,t}) \quad = \quad & \omega_{NP} + \alpha_{NP}|z_{NP,t-1}| + \gamma_{NP} z_{NP,t-1} + \beta_{IN} log(\sigma^2_{NP,t-1}) \\ & +\phi_{US} log(\hat{\sigma}^2_{US,t-1}) + \phi_{IN} log(\hat{\sigma}^2_{IN,t}); z_{NP,t-1} = \frac{\varepsilon_{NP,t-1}}{\sigma_{NP,t-1}} \end{aligned} \tag{10}$$

Variance equation - TGARCH:

$$\begin{aligned} \sigma^2_{NP,t} \quad = \quad & \omega_{NP} + \alpha \varepsilon^2_{NP,t-1} + \gamma_{NP} \varepsilon^2_{t-1} I(\varepsilon_{NP,t-1} < 0) + \beta_{NP} \sigma^2_{NP,t-1} \\ & +\phi_{US} \hat{\sigma}^2_{US,t-1} + \phi_{IN} \hat{\sigma}^2_{IN,t} \end{aligned} \tag{11}$$

Considering time zone differences, we include the lag spillover effect from the US market and contemporaneous spillover effects from the Indian market to the Nepalese market. Now the statistical significance of parameter estimates for δs and ϕs indicates the international spillover effects in the return process and the conditional variance respectively. Note that δ_{US} in Eq. (6) and Eq. (9) can be proxied as global systematic risk given that the US return is considered a global factor; and δ_{IN} can be considered a regional systematic risk as the Indian market is the dominant market in the South Asian region. I therefore expect δs to be positive.

3.3. Data and Sample

This study uses a comprehensive data set to provide evidence of an asymmetric volatility effect in the Nepalese stock market. For a comparative analysis and to capture the international spillover effect I also include the US and Indian stock markets in my sample. The data for the NEPSE index is manually collected data from the SEBON and NEPSE annual reports and other publications from their archives. The data for the US and Indian stock markets are from Refinitiv Datastream using symbols *TOTMKUS* for the US and *TOTMKIN* for India. The data for Nepal is available only from July 1995. The sample period covers from July 17, 1995 to July 19, 2019 for a total of 6264 daily observations. I synchronized the data covering the 5 working days of Monday to Friday, and have used the data lapping technique for synchronization. Considering the geographical difference, Day 02 in Asia = Day 01 in the US.

4. Results and Discussion

4.1. Descriptive Statistics

Figure 1 shows the evolution of the equity market index of Nepal along with the equity markets of the US and India over the last 25 years. For ease of comparison, all three indices are indexed to 100 at the beginning of the sample period. While the evolution of the price process of the Nepalese equity market was somewhat similar to that of the Indian market for the first half of the sample period, it started showing divergent paths during the second half of the sample period, more specifically immediately after the global financial crisis and after mid-2016. Among three indices, while the US equity index follows a smoother path, the Indian and Nepalese equity indices have many episodes of swinging (ups and downs) exhibiting higher volatility in these markets.

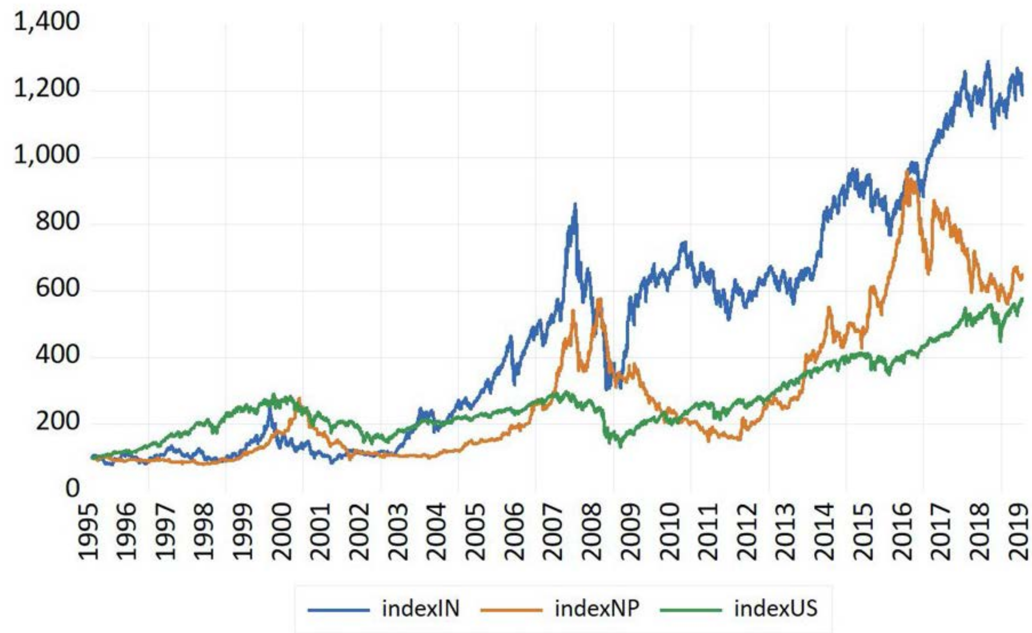

Figure 1. Equity indices for Nepal along with the US and India.

The descriptive statistics of the return series for the returns of three equity market indices are provided in Table 1. All indices display a positive average return over the sample period with a higher return on the NEPSE compared to the US equity index. The high standard deviation reflects the high levels of volatility in equity markets, as do minimum and maximum values. While the return series for Indian and the US equity markets are left-skewed, the return series for the Nepalese equity market is right-skewed. The positive skewness in the NEPSE returns suggests that large positive returns tend to occur more often than large negative returns, that is large positive price changes are not matched by equally large negative price changes. All three return series display excess kurtosis.

Table 1. Descriptive statistics.

	r_{NP}	r_{US}	r_{IN}
Mean	0.030	0.028	0.040
Median	0.000	0.038	0.027
Maximum	10.259	10.902	15.078
Minimum	-10.069	-9.409	-12.593
Std. Dev.	1.121	1.150	1.425
Skewness	0.203	-0.288	-0.360
Kurtosis	16.418	11.339	11.036
Observations	6264	6264	6264

Note: r_{NP}, r_{US} and r_{IN} refer to return on the NEPSE index, return on the US equity index, and return on the Indian equity index respectively. The sample period is from July 17, 1995 to July 19, 2019.

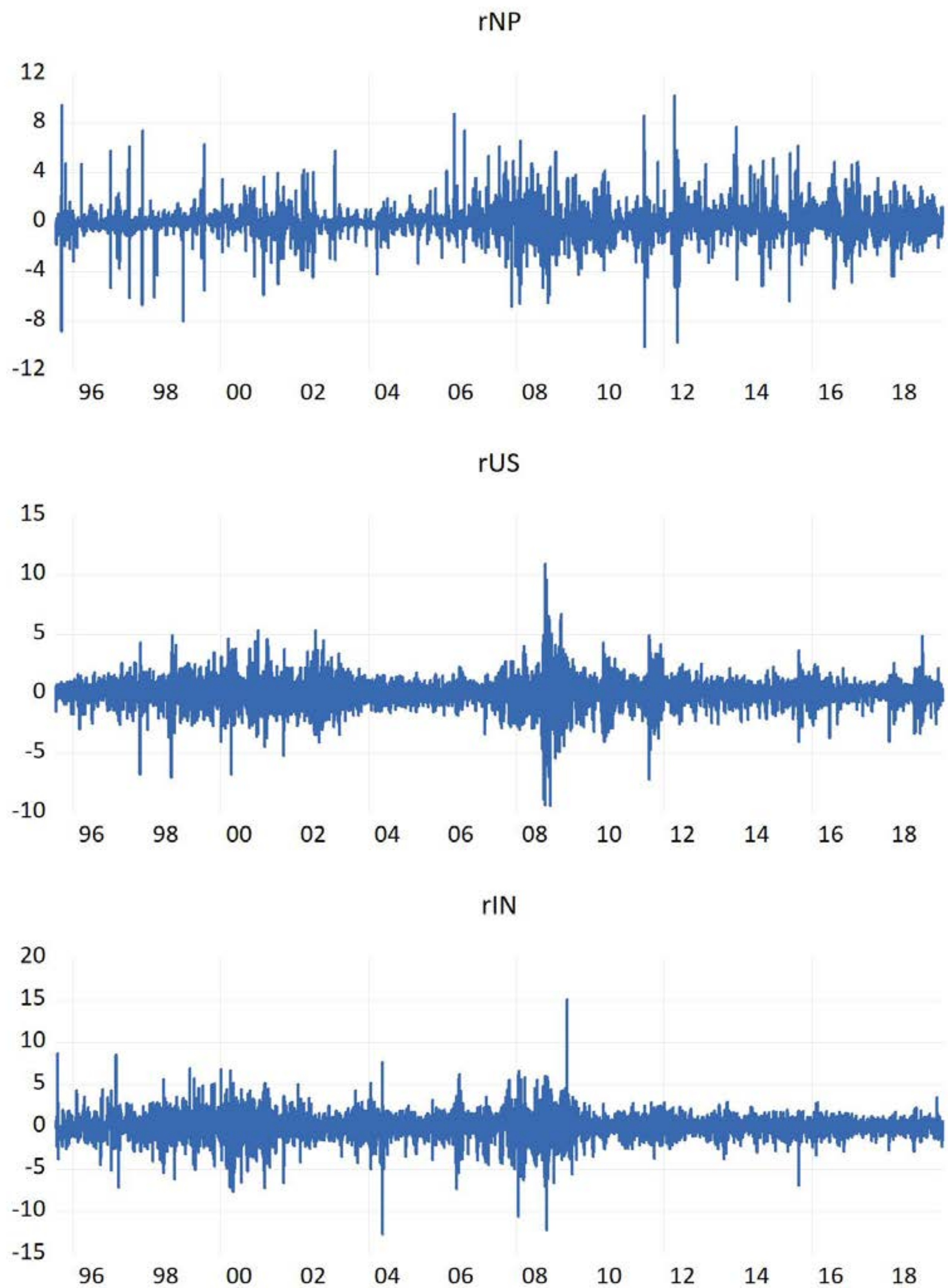

Figure 2. Equity returns.

Figure 2 plots the return series and shows that the Nepalese stock market remains volatile all the time with some exceptions around 2002–2006 as evident from many spikes (positive and negative). The Indian stock market exhibited less volatility after the global financial crisis. The graph also clearly shows volatility clustering in all three stock markets - large changes in price tend to be followed by large changes, and small movements are followed by small movements. Such volatility clustering indicates that volatility shocks today will influence the expected volatility of some periods in the future. Such heteroskedasticity in return series' demonstrates our choice of the GARCH framework for modeling volatility for these markets.

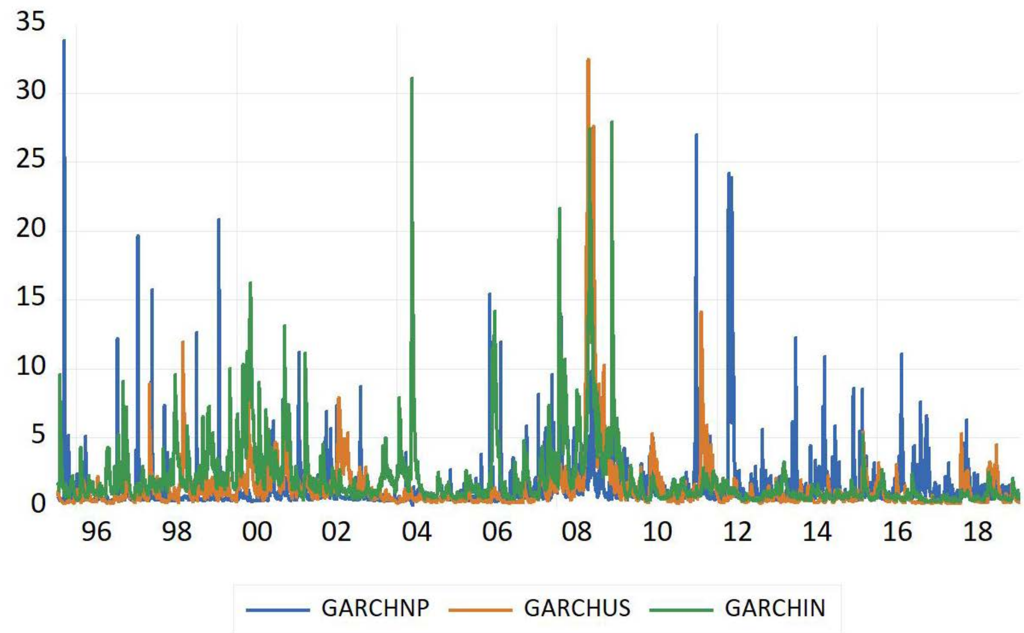

Figure 3. Conditional variances.

Note: GARCHNP, GARCHUS, and GARCHIN refer to conditional variances for the equity return series of Nepal, the US, and India respectively. The conditional variances are estimated from Eq. (2), the GARCH(1,1) process.

The conditional variances derived from the GARCH (1,1) process are presented in Figure 3. From the figure, we can see very large conditional variances in the Nepalese stock market in five early years and eight later years of the sample period and generally higher market volatility than the Indian and US equity market during these periods. During the global financial crisis, the US market was the most volatile among the three. The Indian market exhibited high volatility for the period of early 2000 until the end of the global financial crisis in 2009.

4.2. GARCH Results

The results from the EGARCH and TGARCH models for the Nepalese stock market along with the equity markets of the US and India are reported in Table 2. While results from both the asymmetric GARCH models are consistent and very similar, for ease of discussion I follow results from the EGARCH model(s).

The autoregressive coefficient estimate θ in the mean equation is statistically and economically significant for Nepal and India. The autocorrelation is about 17% for Nepal and about 12% for India. The results suggest that the returns on these stock markets are predictive. The price process in these markets follows the continuation of apparent past 'trends' in prices, and investors are optimistic in bull markets and pessimistic in bear markets. The positive autocorrelation is also consistent with ideas put forward by Campbell et al. (1993) and Avramov et al. (2006) who argue that non-zero autocorrelation implies trading of uninformed investors whereas zero autocorrelation implies trading of informed investors. The finding of autocorrelation also implies that these markets are less efficient and have a strong presence of noise traders. However, that is not the case for the US where the coefficient estimate for θ is not statistically significant owing to the higher level of market efficiency in the US equity market. Our results align with the literature that the returns in emerging markets are predictable (Bekaert & Harvey, 1997).

Table 2. Results from asymmetric GARCH models.

	EGARCH			TGARCH		
	Nepal	US	India	Nepal	US	India
Mean equation						
μ	0.0585	0.0306	0.0431	0.0039	0.0279	0.0424
	0.0061	0.0098	0.0125	0.0114	0.0105	0.0132
	0.0000	*0.0019*	*0.0006*	*0.7344*	*0.0077*	*0.0014*
θ	0.1737	-0.0057	0.1169	0.1237	-0.0083	0.1095
	0.0138	0.0128	0.0135	0.0155	0.0133	0.0135
	0.0000	*0.6569*	*0.0000*	*0.0000*	*0.5354*	*0.0000*
Variance equation						
ω	-0.1920	-0.1079	-0.1810	0.1065	0.0197	0.0319
	0.0032	0.0058	0.0054	0.0028	0.0014	0.0029
	0.0000	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*
α	0.3260	0.1361	0.2651	0.2076	0.0076	0.0727
	0.0055	0.0072	0.0066	0.0065	0.0045	0.0056
	0.0000	*0.0000*	*0.0000*	*0.0000*	*0.0882*	*0.0000*
γ	0.0315	-0.1400	-0.0724	-0.0409	0.1752	0.0750
	0.0042	0.0054	0.0048	0.0080	0.0082	0.0071
	0.0000	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*
β	0.8796	0.9751	0.9653	0.7448	0.9001	0.8782
	0.0027	0.0016	0.0023	0.0053	0.0053	0.0051
	0.0000	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*
Log likelihood	-8720.2	-8303.7	-10042.7	-8652.3	-8313.1	-10012.5
AIC	2.7866	2.6536	3.2089	2.7649	2.6566	3.1993
BIC	2.7931	2.6601	3.2154	2.7714	2.6630	3.2057

Note: Standard errors are displayed below the coefficient estimates and p-values are given in italics below the standard errors.

The results for the variance equation show that the ARCH effect (α) and GARCH effect (β) are statistically significant and positive for all the markets, suggesting that return shocks increase volatility and that volatility is time varying. My primary focus is on the asymmetric volatility. The results for all three equity markets have statistically significant estimates for γ. While the sign of the coefficient estimate is negative for the US and Indian markets, the sign of the coefficient estimate for the Nepalese stock market is positive.[4] The positive coefficient implies that positive shocks increase volatility by more than negative shocks. In other words, when good news hits the market, stock prices react favorably, causing volatility to rise. While the asymmetric effect results for the US and India are as anticipated and align with the existing literature (Bekaert & Wu, 2000), the inverted asymmetric results for equity markets have rarely been found in the literature.

The inverted asymmetric effect in the Nepalese equity market could be explained by its innate institutional features. The Nepalese stock market is very young and investing in stocks (trading) is a recent phenomenon. There is a lack of institutional investor trading on the Nepalese stock market (Paudel, 2010) and trading is done largely by individual investors. Investors may not be well-informed and may trade based on incomplete information or even trade irrationally (often referred to as noise traders). The individual investors with no or less information act on noise as if it were information that would give them an edge (Black, 1986). Whenever good news on the market comes out, noise traders in Nepal rush to put money on the stock market expecting to have higher returns. Hellwig (1980) and Wang (1993) state that trading of uninformed investors leads to a rise in volatility while informed trading reduces it. Avramov et al. (2006) argue that price changes due to uninformed investors will be reversed, increasing volatility by more than price changes due to informed investors. The results for γ, along with the positive sign of estimate for the θ, the AR(1) coefficient, indicate that uninformed investors play a significant role in the Nepalese stock market, in line with Avramov et al. (2006).

The investor behaviors captured in these results are also consistent with phenomena such as "fear of missing out" (FOMO), pump and dump schemes, and the disposition effect. If uninformed investors drive up prices due to a fear of missing out in rising markets, volatility will increase by more than in falling markets. If uninformed investors pump up prices as part of a pump and dump scheme, volatility will increase by more than in falling markets (Baur & Dimpfl, 2018). In these cases uninformed investors are driving up prices to levels that are reversed and corrected by informed investors, establishing the asymmetric volatility effect. The asymmetry is also consistent with the disposition effect in the absence of informed investors if uninformed investors are more likely to sell in rising markets than in falling markets, implying a reversal and higher volatility in rising markets and no reversal and lower volatility in falling markets. The results indicate that the behavior of investors in the Nepalese stock market is somewhat similar to the investors in the cryptocurrency market (Baur & Dimpfl, 2018).

Furthermore, as postulated by French and Roll (1986) trading itself can speed up the flow of information and introduce noise into stock returns thereby increasing volatility. Paudel and Shrestha (2019) find a positive relationship between trading volume and stock returns in the Nepalese stock market. In general, an increase in trading volume will result in an increase in return volatility. In good-news-chasing behavior, the level of increasing return volatility resulting from the increasing trading volume due to good news shocks is greater than that resulting from bad news shocks (Yeh & Lee, 2000). If investors tend to chase good news, the increased trading volume will amplify the volatility of the returns. Therefore, the results for inverted asymmetric volatility effects suggest that good news shocks in the Nepalese stock market attract investors, which leads to an increase in return volatility. Yeh and Lee (2000) find similar good-news-chasing behavior of investors in Chinese stock markets.

4.3. International Spillover Effects

Table 3 provides results for the international spillover effects. Note that I include the US and Indian spillover effects on the Nepalese equity market along with the US spillover effect on the Indian equity market. The results for first order autoregressive term, arch effect and GARCH effect and asymmetric volatility effect are similar to the results provided in Table 2. The results for the spillover effects on the mean equation for Nepal suggests that there is no spillover effect from the US stock market. The coefficient estimate is not statistically significant at the 0.05 level. The results are quite unexpected; the US equity market is often considered a leading market and works as a global factor. Therefore from the international capital asset pricing model (CAPM) perspective, the Nepalese stock market is not systematically linked to the global stock market. In other words, the Nepalese stock market is not integrated with the global stock market at all. The results could be due to the very small size of the Nepalese equity market, and the fact that the Nepalese economy is less connected to international markets through trade and financial linkages.

The spillover effect from the Indian stock market to the Nepalese stock market however is statistically significant but yet negative. With India being Nepal's largest trading partner, and the Indian market being the largest and most influential market in South Asia, the effect should be positive. The negative and statistically significant coefficient may imply that investors who are taking part in trading in these neighboring markets may adjust their portfolio and consider an alternative market for portfolio rebalancing. In other words, investors can diversify their portfolio risk by investing in both markets rather than investing in only one market. The fixed exchange rate between Indian currency and Nepalese currency makes it even attractive.[5]

The mean spillover effect from the US to Indian stock market however is different - there is a positive and statistically significant effect from the US stock market. The impact is also economically significant as indicated by the relatively large coefficient – about a 1% point change in the US stock market performance will lead to about a 0.19% point change in Indian stock market performance. Such statistically and economically significant spillover effects on the Indian stock market could be attributed to a higher level of economic and financial linkages between the Indian market and the US market. The literature suggests that a higher level of economic integration makes markets vulnerable to spillover effects (Bekaert et al., 2009; Dungey & Gajurel, 2015).

Table 3. Results for international spillover effects.

	EGARCH		TGARCH	
	Nepal	India	Nepal	India
Mean equation				
μ	0.0571	0.0337	0.0060	0.0353
	0.0070	0.0125	0.0115	0.0130
	0.0000	*0.0070*	*0.6039*	*0.0067*
θ	0.1716	0.0818	0.1221	0.0812
	0.0141	0.0126	0.0154	0.0133
	0.0000	*0.0000*	*0.0000*	*0.0000*
δ_{US}	0.0006	0.1901	0.0056	0.1921
	0.0086	0.0132	0.0101	0.0132
	0.9434	*0.0000*	*0.5799*	*0.0000*
δ_{IN}	-0.0127		-0.0149	
	0.0047		0.0049	
	0.0064		*0.0026*	
Variance equation				
ω	-0.1842	-0.1524	0.1062	0.0266
	0.0034	0.0064	0.0030	0.0027
	0.0000	*0.0000*	*0.0000*	*0.0000*
α	0.3250	0.2221	0.2178	0.0748
	0.0056	0.0088	0.0069	0.0059
	0.0000	*0.0000*	*0.0000*	*0.0000*
γ	0.0345	-0.0567	-0.0528	0.0675
	0.0042	0.0048	0.0084	0.0072
	0.0000	*0.0000*	*0.0000*	*0.0000*
β	0.8782	0.9705	0.7366	0.8767
	0.0028	0.0028	0.0054	0.0056
	0.0000	*0.0000*	*0.0000*	*0.0000*
ϕ_{US}	0.0199	0.0089	0.0121	0.0078
	0.0017	0.0023	0.0010	0.0019
	0.0000	*0.0001*	*0.0000*	*0.0000*
ϕ_{IN}	-0.0120		-0.0049	
	0.0024		0.0004	
	0.0000		*0.0000*	
Log likelihood	-8705.5	-9926.7	-8633.3	-9917.9
AIC	2.7836	3.1730	2.7605	3.1702
BIC	2.7944	3.1816	2.7713	3.1788

Note: Standard errors are displayed below the coefficient estimates and p-values are given in italics below the standard errors.

While assessing the volatility spillovers, we however find that the volatility of Nepalese and Indian equity markets are influenced by the volatility of the US market. The spillover effect of the volatility of the Indian market on the volatility of the Nepalese stock market is negative and statistically significant - aligning more with the mean equation results. The negative effect of the Indian stock market on the Nepalese stock market (both in return and volatility), along with the findings of the previous section may signal the presence of potential market manipulation in the Nepalese stock market. As there are a limited number of big investors and a large number of small investors, a lack of institutional investors, and a lack of strong security exchange/investor protection laws and institutions, the market can be manipulated.

4.4. Robustness of Results

The results are robust to different checks. I also examine the asymmetric volatility effect using non-synchronized data for NEPSE without international spillover effects. There are 7227 non-synchronized data for NEPSE as the trading floor opens 6 days a week (Sunday to Friday). The results are very similar. Furthermore, considering the potential for fat tails in returns series, the GARCH models are re-estimated with a Generalized Error Distribution. The results are robust to alternative error distribution specifications. In the interest of brevity, the results are not reported here and are available from the author upon request. Considering the functional form specified in Eq. (6), I reestimate Eq. (9) by orthogolizing the international spillover factors. More specifically, I replace r_{IN} with ε_{IN}. The results are robust.

5. Conclusion

In this paper, by analyzing the asymmetric volatility of the Nepalese stock market I identify a distinguishing feature. I find that volatility increases more in response to positive shocks than in response to negative shocks. The inverted asymmetric effect is in contrast to the results for the US and Indian markets and the results reported for other international stock markets in the literature. I also find a positive autocorrelation of returns indicating that noise trading activity dominates the market. The results further show that the Nepalese stock market is not exposed to the global stock market, yet is negatively correlated with the Indian stock market.

The results showing an inverted asymmetric volatility effect, positive autocorrelation, and negative comovement with the Indian stock market suggest that "fear of missing out" of noise traders as well as the deployment of pump and dump schemes are inherent features of the Nepalese stock market. Therefore, it is strongly recommended that the regulators undertake a thorough investigation of potential pump and dump schemes in the Nepalese stock market, protecting the interests of general investors. It is also urged to come up with a financial literacy program for general investors. NEPSE should keep thorough records of the transaction details and provide this data to researchers. Easy access to more detailed data will help to unfold many hidden stories embedded in trading activities in the Nepalese stock market. A potential avenue for further research would be to study market manipulation.

Endnotes

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[3] The sample includes the US, Canada, Mexico, Brazil, the UK, Germany, France, Greece, the Czech Republic, Spain, Italy, Japan, Australia, Hong Kong, Korea, India, and Singapore.

[4] Note that in the TGARCH model, the sign of is opposite of that in the EGARCH model. The econometric/financial interpretation, however, remains the same.

[5] Nepal follows a pegged exchange rate system anchoring its currency with Indian currency. For a long time, it has been pegged at Indian Rs. 100 = Nepalese Rs. 160.

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