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VOLATILITY SPILLOVERS OF RUPEE-DOLLAR AND RUPEE-EURO EXCHANGE RATES ON INDIAN STOCK PRICES: EVIDENCE FROM GARCH MODEL

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Abstract

This paper examines the effect of volatility in both rupee-dollar and rupee-euro exchange rates on stock prices in India using daily data from 3-Apr-2007 to 30-Mar-2012. Adopting a generalized autoregressive conditional heteroskedasticity (GARCH) and exponential GARCH (EGARCH) model, the study suggests a negative relationship between exchange rate and stock prices in India. Even though India is a major trade partner of European Union, the study couldn't find any significant statistical effect of fluctuations in Euro-rupee exchange rates on stock prices, while the effect of fluctuations in Dollar-rupee exchange rates on stock prices is highly significant. The study also reveals that shocks to exchange rate have symmetric effect on stock prices and exchange rate fluctuations have permanent effects on stock price volatility in India.

Keywords: Exchange rate, Stock Price, Unit root, GARCH and India

Introduction

Foreign exchange market and stock market are the most important constituents of a financial system. Foreign exchange market deals in foreign exchange and it is reflected in exchange rates, as stock market deals in shares of corporate and it is reflected by share prices. In recent years, the intellectual curiosity of researchers and investors has much focused to examine the link between exchange rate and stock price. This is partly due to the advent of floating exchange rate regime, relaxation of Government control over international trade and adoption of liberal policy regarding import and removal of restriction on foreign investment. Many factors, such as enterprise performance, dividends, stock prices of other countries, gross domestic product, exchange rates, interest rates, current account, money supply, employment, their information etc. have an impact on daily stock prices [Kurihara (2006)]. Kim (2003) has

reported that the unprecedented increases in the volume of world trade and free capital movements across the nations have increased the role of exchange rate in profitability and equity prices.

Exchange rate is one of the important and most confusing risk elements in the stock market. There is a common belief that, stock prices are significantly affected by ups and downs in the exchange rate. The variation in exchange rate affects the firm value and the firm value is reflected in its share prices. A booming stock market will attract foreign investment, and it will lead to the inflow of foreign exchange and the resulting rise in the value of domestic currency. The opposite also may happen in case of falling stock prices. In an open economy, the expectations of relative currency values influence the level of domestic and foreign interest rates, which in turn affect the present value of a firm's assets. Similarly the firms and corporations use the foreign exchange market for a variety of purposes related to their operations such as payment for imports, conversion of export receipts, hedging of receivables and payables, payment of interest on foreign currency loans, placement of surplus funds and so forth. This suggests that exchange rates play a crucial role in the movement of stock prices.

Theoretical explanations

The theoretical support for the impact of exchange rate on stock prices is very strong. The impact of exchange rates on stock prices can be explained with the help of two approaches, one is goods market approaches and another one is Portfolio balance approach.

Goods market approach by Dombusch and Fischer suggest that changes in exchange rates affect the competitiveness of a firm as fluctuations in exchange rate affects the value of the earnings and cost of its funds as many companies borrow in foreign currencies to fund their operations and hence its stock price. A depreciation of the local currency makes exporting goods attractive and leads to an increase in foreign demand and hence revenue for the firm and its value would appreciate and hence the stock prices. On the other hand, an appreciation of the

local currency decreases profits for an exporting firm because it leads to a decrease in foreign demand of its products. We can conclude from the above premises that appreciation in exchange rate is negatively related to the stock prices of the exporting firm and positively related to stock price of importing firm.

Portfolio balanced approach stresses that exchange rate are determined by the fluctuation in the equity market and work under the demand and supply framework. An upward moving stock market of the country grabs the attention of the foreign investors to invest in the stock and diversify their portfolios; hence the upward movement brings more foreign currency to the country and increases the demand for the local currency, which leads to appreciation of the local currency. On the other side, when the stock market falls, the stocks lose its attraction to be added in the portfolio. And the investors then sell out their stocks to avoid further losses this leads to lower demand for local currency and the local currency depreciates. As a result the upward (downward) movement of the stock market of country will lead to appreciate (depreciate) the exchange rate of the country.

Literature Review

While both goods market and portfolio theory suggests that changes in exchange rate can have an important impact on the stock price, there is no conclusive empirical results has established. Some studies support negative association, while some studies support positive relation. The early studies, which examined the stock price-exchange rate link shows no valid pattern of responses by stock prices to exchange rate. [See, Ang and Ghallab (1976); Franck and Young (1972)]. This result may be attributed to the fixed exchange rate regime of BrettonWoods era. After the advent of floating exchange rate regime, the role of exchange rate in influencing macroeconomic and financial variables has been heightened.

Aggarwal (1981) was the first to examine the link between stock price and exchange rate and found a positive significant correlation between the two variables in U.S. On the other hand

the studies by Soenen and Hennigar (1988), Goodwin et.al; (1992), Ibrahim and Aziz (2003) and Kim (2003), suggested a negative link between the stock prices and the exchange rates. As a contrary to the above said studies Solnik (1987) and Ong and Izan (1999) suggested that changes in exchange rates do not have any significant impact over stock prices.

Enormous number of studies has been examined the causal relationship between exchange rate and stock price using granger causality technique. Some studies support a unidirectional causality from exchange rate to stock price; some studies from stock price to exchange rate and some studies support bidirectional causality. Most of the studies suggested a unidirectional causality from stock price to exchange rate. Bhmani et.al; (1992) examined both short run and long run relationship between stock price and exchange rate and found a one way causal relationships from stock prices to exchange rates in short run, and no causal relationship in the long run. Libly (1993) suggested a unidirectional causality which moves from stock prices to exchange rate. The study by Ajayi et al (1998) reported a one way causal relation from the stock market to the exchange rate in Indonesia and the Philippines, while in Korea it runs in the opposite direction. They couldn't find any significant relation in Hong Kong, Singapore, Thailand, or Malaysia. However, in Taiwan, they detected a two-way relationship. Granger, Huang and Yang (2000) conducted a detailed study of the Philippine and South Korean market and concluded that in Philippine the unidirectional causality exists between stock market and exchange rate, and the direction of the causality is from stock price to exchange rates. Mansoor (2000), found no long run relationship between stock prices and exchange rates, but found unidirectional causal relationship from stock prices to exchange rates in short run. Hatemi-J and Irandoust (2002) suggested a unidirectional causality running from stock prices to exchange rates. On the contrary to above study Yu (1997) detected a unidirectional causality from exchange rates to stock prices for Singapore, and bidirectional causality for Tokyo Market during the period from 1983 to 1994.

A detailed study made by Erbaykal and Okuyan (2007) for 13 developing countries suggested a unidirectional causality from stock price to exchange rates in the five countries, a bidirectional causality in the three economies and no relation found in remaining economies. Similarly Doong et al. (2005) studied the relationship between stock price and exchange rate for Asian countries and detected bidirectional causality in Indonesia, Korea, Malaysia, and Thailand.

A sizable number of studies have tried to examine the long run association using cointegration approach. Nieh and Lee (2001) examine the relationship between stock prices and exchange rates for G-7 countries and find that there is no long-run equilibrium relationship between stock prices and exchange rates for each G-7 countries. Similarly by taking 45 years of U.S quarterly data, Ozair (2006) investigated the link between stock prices and exchange rates and showed no causal linkage and no cointegration between these two financial variables.

The studies on the link between exchange rate and stock market are relatively spheres in India and the existed studies shows mixed results. One of the earliest studies conducted by Abdalla and Murinde (1997) detected a unidirectional causality from exchange rate to stock prices in India. Smyth and Nandha (2003) also find a unidirectional causality running from exchange rates to stock prices for India and Sri Lanka. On the contrary to the above result, Muhammad and Rasheed's (2002) study on the exchange rates and stock price relationships for Pakistan, India, Bangladesh and Sri Lanka shows no any significant relation between exchange rates and stock prices in India.. Similarly Bhattacharya and Mukherjee (2003) suggested that there is no significant relationship between stock prices and exchange rates in India.

Even though, there are enormous studies focusing on exchange rate and stock price relationships, to the best of our knowledge, we find some drawbacks of existing works. Firstly, no studies examined both the dollar and euro exchange rate on Indian stock market. Second, the studies that examined the link between exchange rate and stock prices overwhelmingly applied

the traditional econometric tool of Granger causality test and cointegration. The studies with the application of new financial econometrics model such as GARCH and EGARCH model are hard to find.

The main objective of the paper is to examine the effects of both dollar-rupee exchange rates and euro-rupee exchange rates on two major stock price indices in India such as S&P NIFTY and SENSEX. The Indian financial sector has witnessed dramatic changes since the inception of financial sector reforms in the early 1990s. India has adopted a managed floating exchange rate regime, which facilitates greater international trade and increased the volatility in exchange rate. Since India abolished the restriction on foreign investment in Indian equities, the equity market also began to volatile. In India both equity and forex market are interdependent and most sensitive segment of the economy. So it is of the crucial importance to trace out the relationship between exchange rate and stock prices.

Data and Methodologies

In order to examine the link between exchange rate and stock prices in India, the following secondary data are used. We select rupee-euro and rupee-dollar exchange rates for exchange rates and S&P CNX NIFTY and BSE30 SENSEX to represent stock price. We select euro as it considered as second most widely used currency at the international level after dollar. The data are collected on both daily bases over a period of 3-Apr-2007 to 30-Mar-2012.

The daily data on rupee-euro and rupee-dollar exchange rates are collected from Handbook of Statistics on Indian Economy (www.rbi.org.in), while the daily data on S&P CNX NIFTY and BSE30 SENSEX are collected from the official website of National Stock Exchange (NSE) and Bombay Stock Exchange (BSE) respectively. The statistical and time series properties of each and every variable have examined using the conventional unit root such as ADF and PP test. In order to check for the link between exchange rate and stock price, return on exchange rate and stock price are used and employed GARCH and EGARCH models.

The conventional econometric models keep the variance of the disturbance term as constant over time, but exchange rate and stock price series exhibit volatility clustering, ie in some period a unusually high volatility followed by more tranquil periods of low volatility. There for in such cases it is clear that the assumption of constant variance is limiting and application of OLS method provides biased variance estimate; hence, inference based on OLS estimates will be misleading. So in such cases, it is better to examine not the unconditional variance but the conditional variance. For that we employ generalized autoregressive conditional heteroskedasticity (GARCH) of Bollerslev and exponential GARCH (EGARCH) of Nelson for daily data to investigate the link between exchange rate and stock price.

The returns on exchange rate and stock price can be calculated using the following formula,

$$r_t = \log(\frac{y_t}{y_{t-1}})$$

Where y_t and y_{t-1} are exchange rate and stock prices for the periods t and t-1. Let denotes grdo, greur, grnif and grsen be the daily returns on dollar-rupee exchange rate, euro-rupee exchange rate, nifty and sensex respectively.

The general form of Mean and GARCH-M Equation can be written as

$$gry_t = \alpha + \beta x_t + \varepsilon_t$$

We can also consider alternative mean equation, which can be written as

$$gry_t = \alpha + \beta x_t + \xi\sigma_t^2 + \varepsilon_t$$

The variance equation for both GARCH and GARCH-M model can be written as

$$\sigma_t^2 = \psi + \mu_1 \varepsilon^2_{t-p} + \mu_2 \varepsilon^2_{t-q}$$

The variance equation for the EGARCH model can be written as

$$\log(\sigma t^2) = \psi + \delta(\left|\frac{\varepsilon_{t-p}}{\sigma_{t-q}}\right| - \sqrt{\frac{2}{\pi}}) + \gamma\frac{\varepsilon_{t-p}}{\sigma_{t-q}} + \lambda\log(\sigma^2_{t-q})$$

Empirical Results

Table (1)

Descriptive statistics

	gsensex	gnifty	gdoll	geur
Mean	0.000267	0.000300	0.000142	0.000142
Std.dev	0.019156	0.019021	0.005572	0.007180
Skewness	0.263358	0.157905	-0.056593	-0.112767
Kurtosis	9.423479	10.49928	5.731947	5.184980
Jarque-Bera	2080.387	2821.641	374.4404	241.6522
Observations	1202	1202	1202	1202

Table (2)
Contemporaneous Correlation Coefficients

	gsensex	gnifty	gdoll	geur
gsensex	1.000000			
gnifty	0.990673	1.000000		
gdoll	-0.346526	-0.344926	1.000000	
geur	-0.077622	-0.062279	0.307641	1.000000

The table (1) gives a detailed descriptive statistics of all study variables. The mean shows the average returns, in which nifty has highest returns followed by sensex among stock prices. Among exchange rates, euro has highest return followed by dollar. Sensex has highest volatility followed by nifty as indicated by the coefficient of variation which indicates the highest standard deviation relative to the mean. Among exchange rates, euro has the highest volatility. The table (2) gives the correlation among the variables. As expected, sensex and nifty has the highest positive correlation, which is close to one. Similarly both dollar and euro exchange rate has positive correlation. On the other hand both stock prices and exchange rates has negative related.

Figure (1) Return series

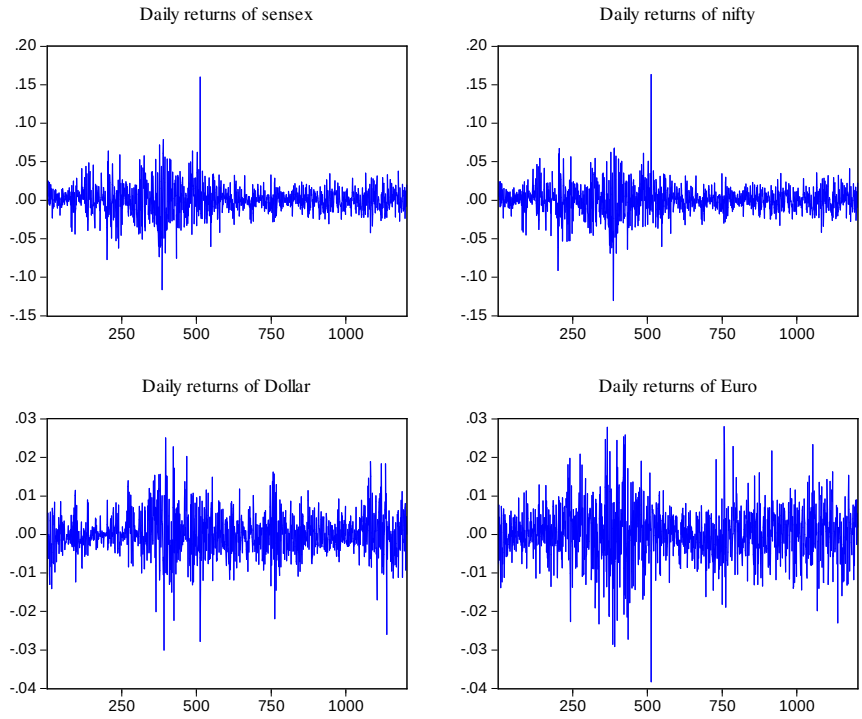

Table (3)

Unit root test results

Variables (Level)	**ADF**		**PP**	
	intercept	Trend& intercept	intercept	Trend& intercept
gsensex	-32.0660	-32.0547	-31.972	-31.960
gnifty	-32.5112	-32.5002	-32.453	-32.441
gdol	-34.1546	-34.1516	-34.233	-34.228
geur	-34.1628	-34.1487	-34.162	-34.148

All values are t statistics

The table 3 shows a series of Augmented Dickey-Fuller and Philip-Perron unit root test results of daily return series; we are able reject the null hypothesis of unit root at 1% level of significance. Thus, all series are stationary.

Table (4)
Estimation result of the model I

Parameters	Dollar on sensex				Dollar on nifty			
	OLS	**GARCH(1,1)**	**GARCH-M(1,1)**	**EGARCH(1,1)**	**OLS**	**GARCH(1,1)**	**GARCH-M(1,1)**	**EGARCH(1,1)**
I. Mean equation								
α	0.00043	0.00066	0.00048	0.0004	0.000468	0.00069	0.00048	0.00040
	(0.4005)	(0.0695)	(0.3622)	(0.2396)	(0.3645)	(0.0665)	(0.3880)	(0.2960)
β	-1.19123	-0.96748	-0.9678	-0.9568	-1.177372	-0.98757	-0.98798	-0.97271
	(0.000)	(0.000)	(0.000)	(0.0000)	(0.000)	(0.000)	(0.000)	(0.0000)
ζ	___	___	1.02627	___	___	___	1.15933	___
			(0.662)				(0.6405)	
II. Variance equation	___	2.59E-06	2.59E-06	-0.2884	___	2.97E-06	2.98E-06	-0.32370
w		(0.0695)	(0.0042)	(0.000)		(0.0023)	(0.0027)	(0.000)
μ1	___	0.091519	0.09161	___	___	0.097772	0.09807	___
		(0.0000)	(0.0000)			(0.0000)	(0.0000)	
μ2	___	0.903447	0.90335	___	___	0.897505	0.89720	___
		(0.000)	(0.0000)			(0.000)	(0.0000)	
δ	___	___	___	0.19536	___	___	___	0.20812
				(0.0000)				(0.0000)
γ	___	___	___	-0.06067	___	___	___	-0.07188
				(0.000)				(0.000)
λ	___	___	___	0.98340	___	___	___	0.98026
				(0.0000)				(0.0000)
III. Diagnostic	13.259	4.4008	4.4001	4.2703	11.477	4.3994	4.4083	4.3892
Q-Stat (5)	(0.021)	(0.493)	(0.493)	(0.511)	(0.043)	(0.493)	(0.492)	(0.495)
	22.736	8.9402	9.1019	9.7035	22.560	9.8634	10.090	10.909
Q-Stat (15)	(0.090)	(0.881)	(0.872)	(0.838)	(0.094)	(0.828)	(0.814)	(0.759)
	52.836	35.421	35.565	36.192	55.231	37.761	37.988	39.020
Q-Stat (36)	(0.035)	(0.496)	(0.489)	(0.460)	(0.021)	(0.389)	(0.379)	(0.336)
	15.52928	0.0058	0.00843	0.2860	13.8687	0.03452	0.0475	0.07402
LM test (1)	(0.0001)	(0.939)	(0.9268)	(0.592)	(0.0002)	(0.8526)	(0.8274)	(0.7856)

Table (5)
Estimation result of the model II

Parameters	Euro on sensex				Euro on nifty			
	OLS	**GARCH(1,1)**	**GARCH-M(1,1)**	**EGARCH(1,1)**	**OLS**	**GARCH(1,1)**	**GARCH-M(1,1)**	**EGARCH(1,1)**
I. Mean equation								
α	0.000296	0.000783	0.000676	0.00037	0.000324	0.000804	0.000667	0.00055
	(0.5908)	(0.0473)	(0.2488)	(0.3175)	(0.5547)	(0.0489)	(0.2818)	(0.1664)
β	-0.207097	-0.077072	-0.07712	-0.07023	-0.164991	-0.069554	-0.069691	-0.06874
	(0.0071)	(0.1736)	(0.1735)	(0.2420)	(0.0308)	(0.2221)	(0.2216)	(0.2652)
ζ	___	___	0.51243	___	___	___	0.633454	___
			(0.8227)				(0.7931)	
II. Variance equation	___							
w		3.66E-06	3.65E-06	-0.33991	___	4.15E-06	4.15E-06	-0.40131
		(0.0001)	(0.0002)	(0.000)		(0.0001)	(0.0001)	(0.000)
μ1	___	0.092159	0.09202	___	___	0.098288	0.09820	___
		(0.0000)	(0.0000)			(0.0000)	(0.0000)	
μ2	___	0.900465	0.900594	___	___	0.894734	0.89482	___
		(0.000)	(0.0000)			(0.000)	(0.0000)	
δ	___	___	___	0.206521	___	___	___	0.226833
				(0.0000)				(0.0000)
γ	___	___	___	-0.06320	___	___	___	-0.07398
				(0.000)				(0.000)
λ	___	___	___	0.97785	___	___	___	0.97219
				(0.0000)				(0.0000)
III. Diagnostic								
Q-Stat (5)	12.255	6.4824	6.4600	5.4855	8.8077	5.1657	5.1553	4.7247
	(0.031)	(0.262)	(0.264)	(0.360)	(0.017)	(0.396)	(0.397)	(0.450)
Q-Stat (15)	20.907	10.836	10.925	11.030	19.724	11.245	11.396	12.442
	(0.040)	(0.764)	(0.758)	(0.750)	(0.018)	(0.735)	(0.724)	(0.645)
Q-Stat (36)	49.281	25.901	25.921	28.310	48.477	26.656	26.726	30.424
	(0.069)	(0.893)	(0.893)	(0.816)	(0.080)	(0.872)	(0.869)	(0.731)
LM test (1)	21.0848	0.18681	0.18141	0.8825	17.37485	0.06286	0.05563	0.52762
	(0.0000)	(0.6657)	(0.6702)	(0.3477)	(0.0000)	(0.8021)	(0.8136)	(0.4677)

At the first instance, we performed OLS regression on all equations such as dollar on sensex, dollar on nifty, euro on sensex and euro on nifty and found that the variables grdol and greur in both equations are significant at 5% level. Then we checked the model for ARCH effect using Ljung-Box Q-statistics for 5, 15 and 36 lags and also using LM test. This indicates that we are able to reject the null hypothesis of no ARCH effect in all models and we concluded that OLS regression models do suffer from ARCH effect.

As a further step, GARCH (1, 1), GARCH-M (1, 1) and EGARCH (1,1) have been conducted using Maximum Likelihood method. The results of dollar on sensex and nifty are presented in table (4) and (5). The mean equation of GARCH(1,1) shows a negative relation between dollar and both stock price indices. More precisely, increase in both rupee-dollar exchange rates and rupee-euro exchange rates have a negative effect on sensex and nifty. A 10% depreciation of Indian rupee against dollar will leads to 0.96% and 0.98% decreases in sensex and nifty respectively. Similarly 10% depreciation of rupee against euro decreases the sensex and nifty by 0.07% and 0.69% respectively. Regarding the effect, as dollar is considered as a worldwide currency its effect on both stock prices is substantial, while the effect of euro on stock price is very low and it is not statistically significant. Here for all the cases, we found that, the residual is free from autocorrelation and ARCH effect.

The result form GARCH-M (1,1) is listed in the forth column of table 4 and 5, in all cases, the coefficient ζ is found to be insignificant which implies that exchange rate volatility has no impact on the exchange rate itself. Both Q statistics and LM test suggest that, the residual is free from autocorrelation.

The result from EGARCH model is reported in the final column of table 4 and 5. From the mean equations it is confirmed that exchange rate is negatively affecting stock prices, but both the

euro equations show insignificant relations. Coming to the variance equation, the coefficient γ, which measures the asymmetry, is found to be significant at 1% level. This implies that shocks to exchange rate have an asymmetric effect on stock prices, which means positive and negative shocks have different effect on stock prices in terms of magnitude. The volatility persistence term, λ, is positive and statistically significant at 5% level. The coefficient is close to 1, implying that shocks have permanent effect on stock price volatility. The diagnostic check for autocorrelation shows that the model is free from autocorrelation. In short the model is well fitted.

Conclusion

This paper empirically analyzed the impact of fluctuations in both rupee-dollar and rupee-euro exchange rates on stock prices in India for the daily data. The study found that exchange rate and stock price series exhibit volatility clustering, ie in some period a unusually high volatility followed by more tranquil periods of low volatility. So GARCH and EGARCH model has been adopted. The major conclusions of the study are

Firstly, an increase in both rupee-dollar exchange rates and rupee-euro exchange rates has a negative effect on sensex and nifty. A 10% depreciation of Indian rupee against dollar leads to 0.96% and 0.98% decreases in sensex and nifty respectively. Similarly 10% depreciation of rupee against euro decreases the sensex and nifty by 0.07% and 0.69% respectively. Regarding the effect, as dollar is considered as a worldwide currency, its effect on both stock prices is substantial, while the effect of euro on stock price is very low and it is not statistically significant. Even though India is a major trade partner of European Union, we couldn't find any significant statistical effect of fluctuations in Euro-rupee exchange rates on stock prices. Secondly, this study found that shocks to exchange rate have symmetric effect on stock prices, i.e. appreciation and depreciation of rupee

against dollar and euro have similar effects, in terms of magnitude. Thirdly, exchange rate fluctuations have permanent effects on stock price volatility.

This finding will be highly informative to both domestic and foreign investors and financial analysts to understand the direction of relationship between exchange rate and stock prices. For foreign investors, a depreciation of the Indian currency can lead to a portfolio switch from domestic assets, such as stocks, to foreign assets since depreciation reduces returns when these funds are translated to the home currency. For the internationally- diversified domestic investor, the depreciation of the Indian currency would cause foreign stocks to be more expensive. The investor would substitute foreign assets by domestic assets and hence domestic stock price would increase due to increased demand.

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