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Analyzing time–frequency relationship between interest rate, stock price and exchange rate through continuous wavelet

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ABSTRACT

In this study we investigate and identify the patterns of co-movement of interest rate, stock price and exchange rate in India in the period between July 1997 and December 2010 using the cross-wavelet power, the cross-wavelet coherency, and the phase difference methodologies. Our empirical findings suggest that stock prices, exchange rates and interest rates are linked. The cross wavelet results show that stock price movements are lagging both to the exchange rate and interest rate fluctuations. The interest rate lead over the stock price movements is even clearer, especially after 2006, and it suggests that the stock market follows the interest rate signals. Comparing results of WTC and XWT, we find very clear results of phase difference of lead–lag relationship between stock prices, exchange rates and interest rates.

1. Introduction

In recent years, the liberalization of financial markets and the technological advance have increased the interdependence between the stock, foreign exchange and money markets. Stock indexes, exchange rates and interest rates react quickly to the changes of economic fundamentals of countries. Different assumptions in the theoretical models of open-economy macroeconomics have led to dramatically different conclusions on various economic relationships, and often these have hinged on the assumed or derived relationship between bilateral exchange rates and interest rate differentials (Hacker et al., 2012). The dynamic linkages between stock prices, interest rate and exchange rate movements have attracted a special attention from both academics and practitioners. A strong relationship between them would have important implications for economic policies and international capital budgeting decisions because negative shocks affecting one market may be transmitted quickly to another through contagious effects. This issue has become more critical with the occurrence of recent global financial crisis. Given the controversies regarding the nature and direction of these links, a plethora of research activity has emerged on the exchange rate – stock exchange or exchange rate – interest rate co-movements.

Conventional studies that examine the relation between exchange rate and stock return movements tend to focus on the contemporaneous effect of exchange rate changes on stock returns, using mainly the first moments of the relevant distributions, and document either a weak relation or mixed results (Inci and Lee, 2014). Recent research of exchange rates and stock prices co-movement has revealed a strong relationship between the two variables, especially during crisis periods (see, for example, Katechos, 2011; Lin, 2012; Tsai, 2012; Walid et al., 2011). But the research regarding the long-term links between the two variables generally suggest the instability or lack of a relationship (Diamandis and Drakos, 2011; Nath and Samanta, 2003; Phylaktis and Ravazzolo, 2005; Zhao, 2010). Also, the stabilizing effect of the high interest rates during exchange rate crises is contested (Choi and Park, 2008). However, the exchange rate and/or interest rate shocks influence the stock market returns (Ahmad et al., 2010; Pirovano, 2012; Ioannidis and Kontonikas, 2008).

Despite many studies assessed the pair-relations between stock prices, exchange rates and interest rates only few studies have been conducted regarding the joint movement of all three variables (Gupta et al., 2002; Hamrita, 2011; Mok, 1993). The aim of our research is to investigate and identify the patterns of co-movement of interest rate, stock price and exchange rate using the cross-wavelet power, the cross-wavelet coherency, and the phase difference methodologies. The linkages between these three variables have implications for the ongoing attempts to develop stock markets in emerging economies simultaneously with a policy shift towards

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independently floating exchange rates and maintain an independent monetary policy. The main advantage of wavelet analysis is the ability to decompose the data into several time scales and ability to handle non-stationary data and localization in time. Finally the short-run and long-run relationship is clearly established through wavelet time scales, it provides us a holistic picture on the entire relationship (Durai and Bhaduri, 2009). In fact, wavelets are considered as a powerful mathematical tool for signal processing which can provide more insights to co-movement among financial variables via a decomposition of the time series into their time scale component. Particularly, the decomposition into sub-time series and the localization of the interdependence between time series are the two most widely considered area of the wavelet approach in finance (Aloui and Hkiri, 2014).

In this context, the present paper contributes to the existing literature in the following aspects. First, while conventional studies tend to focus on the pair-relations between stock prices, exchange rates and interest rates, we examine the joint movement of all three variables. Second, our analysis is based on the approaches of the cross-wavelet power, the cross-wavelet coherency, and the phase difference that allows us to avoid the non-stationarity problems of the time-series. Also, given the high noise level in financial time series, conventional models may provide us with a distorted picture of economic relationships, tending to reflect average behavior over the states of the economy, rather than their distinctive features.

Third, we study the particular case of an emerging economy, namely India. In the last decade, the Indian economy has witnessed a dramatic transformation from a highly regulated environment to the one that is more market-oriented and has also experienced significant integration with the global economy (Mishra and Sharma, 2011). Despite that numerous studies on the issue have been carried out for U.S. and European countries, the relationship has not been rigorously explored using data from an emerging economy.

The choice of India for this research is motivated by several reasons. According to the World Bank analytical classification of country's development, India is included in the low developed group. The reform efforts during the 1990's allowed one of the fastest increases of the per capita income in the world. Thus while in the period from 1997 to 2006 India was considered a low-income country, after 2007 it joined the lower middle income group. In the 1990's it also adopted exchange rate regimes with high flexibility and, at the same time, progressively eliminated the barriers against capital mobility. According to the IMF, during the analyzed period India adopted a free-floating regime until 2000 and a managed floating arrangement afterwards. The stock market in India has also been exposed to a deep reform during the last two decades. According to Sahoo (2013) the financial deepness, measured as market capitalization-to-GDP ratio, increased sharply, from a 31.2% in 2000 to a maximum of 95.9% in 2010, but has been affected by the recent international turmoil. In 2008 the indicator fell to a 52.7% and in 2011 to 54.9%, following the international financial crisis and, respectively, the European sovereign debt crisis. The Sahoo (2013) analysis reveals, also, that the financial system in India is more biased towards a bank-based one. The country has all the characteristics of a financially open emerging market that makes it very vulnerable to external and internal shocks. Potentially large capital flows influence exchange rate movements and may require monetary policy measures to achieve the macroeconomic objectives (i.e. inflation level, and financial stability). The monetary authorities' actions may generate a co-movement effect of the money market interest rate and exchange rate, at least on a short term and have an indirect effect on the stock market.

Our empirical findings suggest that stock prices, exchange rates and interest rates are linked. Moreover, the direction and type of the relationship depend on the frequency bands and over the time period studied is not the same between pairs of stock–exchange rate, stock–interest rate and exchange rate–interest rate.

The rest of the study is structured as follows. Section 2 reviews the main literature on stock price, exchange rate and interest rate co-movements. Section 3 describes the methodology and data used to investigate the integration of foreign exchange, stock and money markets in India. Section 4 discusses the empirical results and Section 5 concludes.

2. Literature review

The dynamic relationships between stock prices and exchange rates have drawn the attention of numerous economists, both for theoretical and empirical reasons, because they both play crucial roles in influencing the development of a country's economy (Nieh and Lee, 2001). The economic theory has not reached a consensus over the existence or the causality direction of the link between the exchange rates and stock prices. There are two main theoretical approaches – the flow-oriented approach (Dornbusch and Fischer, 1980) and the stock-oriented approach (Frankel, 1984) – which predict opposite effects. The former claims a positive linkage between these two variables, as the exchange rate is determined by the external balance of the country. The stock-oriented approach demonstrates that the exchange rate is determined by the supply and demand of financial assets. Under this approach two models were developed – the portfolio balance model and the monetary model – which claim a negative link between the exchange rates.

A series of research papers focused on the relationship between stock returns and exchange rate changes in order to explain the volatility of the latter. Conventional studies tend to focus on the contemporaneous relation between stock returns and exchange rate changes. In a recent paper, Inci and Lee (2014) examined the effects of stock return changes on exchange rate changes in eight major countries and nine major sectors of their economies. Their methodology employed causal relationships and highlighted the dynamic effects by using lagged variables. They discovered evidence that lagged exchange rates have a significant impact on stock returns and that there was an evidence of Granger causality relation between exchange rates and stock returns, in both directions. More than that, the relation became stronger in the current recession years. Katechos (2011) investigates the foreign exchange — stock market relationship with an alternative approach, he calculates global equity market returns, instead of using the relative equity market performance measures, and finds evidence of a strong link of this variable with the exchange rate. The results show that the sign of the relationship is determined by the level of interest rate on a specific market. Lin (2012) adopts the ARDL model to investigate the co-movement between exchange rates and stock prices in the Asian emerging markets. The results show that this relationship becomes stronger during crisis periods compared to normal periods, suggesting the contagion between the two variables. Moreover, the exchange rate volatility is an effect of the stock price shocks and is driven by the capital account balance rather than that of trade.

Also, the dynamics of the stock price and exchange rate volatility is investigated on a group of emerging countries in different regions of the world: Hong Kong, Singapore, Malaysia and Mexico (Walid et al., 2011). The results show that the periods of high volatility coincide with periods of crises, as Mexican and Asian financial crises, the terrorist attacks of 2001 and the US subprime crisis of 2008. Tsai (2012) arrives to similar results after investigating the presence of the portfolio balance effect in Asian countries. By using quantile regression models, he finds support for portfolio balance effect theory for non-“normal” situations, e.g. financial crises, and market bubbles. During “normal” periods, with no obvious capital flows, in the relationship between these two markets the international trading effect occurs.

Diamandis and Drakos (2011) found out that stock and foreign exchange markets in Latin America are positively linked and that the U.S. stock market acts as a channel for these links. The long run relationships between the two markets are characterized by instability. Yau and Nieh (2009) discovered in Japan and Taiwan, by using a TECM model, a long-