The multiscale causal dynamics of foreign exchange markets[☆]

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ABSTRACT

This paper relies on wavelet multiresolution analysis to investigate the dependence structure and predictability of currency markets across different timescales. It explores the nature and direction of causality among the exchange rates with respect to the US dollar of the most widely traded currencies, namely Euro, Great Britain Pound and Japanese Yen. The timescale analysis involves the estimation of linear, nonlinear and spectral causal relationships of wavelet components and aggregate series as well as the investigation of their out-of-sample predictability. Moreover, this study attempts to probe into the micro-foundations of across-scale causal heterogeneity on the basis of trader behavior with different time horizons. The examined period starts from the introduction of the Euro and covers the dot-com bubble, the financial crisis of 2007–2010 and the Eurozone debt crisis. Technically, this paper presents an invariant discrete wavelet transform that deals efficiently with phase shifts, dyadic-length and boundary effects. It also proposes a new entropy-based methodology for the determination of the optimal decomposition level and a wavelet-based forecasting approach. Overall, there is no

indication of a global causal behavior that dominates at all time-scales. In the out-of-sample analysis wavelets clearly outperform the random walk for the volatility series. Moreover, the synergistic application of wavelet decomposition and artificial neural networks provided with an enhanced predictability in many forecast horizons for the returns. These results may have important implications for market efficiency and predictability.

1. Introduction

Since the pioneering work of Grossmann and Morlet (1984) wavelet methodology, a refinement of Fourier analysis, has been introduced in the literature as an alternative for analyzing nonstationary data with "irregularities". Their contribution was followed by the development of multiresolution analysis by Mallat (1989) and the introduction of orthogonal wavelet bases by Daubechies (1992). Even though the wavelet methodology has widespread application in the natural sciences, it is a rather unexplored area in economics. The wavelet multiscale decomposition, allowing for simultaneous analysis in the time and frequency domain, could be a valuable means of exploring the complex dynamics of financial time series.

In this study we use the wavelet methodology to investigate the dependence structure and predictability of currency markets at different timescales. During the Great Moderation period[2] and in particular during the nineties, currency markets have grown more similar and exchange rate volatility decreased (Laopodis, 1997). More recently, the Euro behavior against the US dollar has seriously altered the prior state of market interrelations (Bénassy-Quéré and Lahrèche-Révil, 2000; Wang et al., 2007). Given the status of the US dollar and Euro as anchor currencies, it is interesting to examine the nature of the causal linkages between them, as well as with other currencies.[3] The existence of causal linkages would suggest that news originating in a specific market is not country-specific and idiosyncratic, but efficiently transmitted to other foreign markets, thus providing support to the "*meteor shower*" notion introduced by Engle et al. (1990). However, it is necessary to go beyond linearity when examining the exchange rate linkages and their forecastability. Meese and Rogoff (1983) reported in their seminal work the failure of linear exchange rate models, whilst according to Ma and Kanas (2000) nonlinear structures may account for bubbles with self-fulfilling expectations (Blanchard and Watson, 1982), target zone models (Krugman, 1991), nonlinear monetary policies (Flood and Isard, 1989) and noise trading (Black, 1986). However, empirical studies that tested for these kinds of nonlinearities have rather failed to support them (Lindberg and Soderlind, 1994). Hence, we need to resort to a more general framework provided by wavelet analysis.

The aim of our paper is was two-fold: first to test for the existence of linear, nonlinear and spectral causal relationships among the three most heavily traded currencies ("FX majors") denoted relative to the United States dollar (USD), namely the Euro (EUR), Great Britain Pound (GBP) and Japanese Yen (JPY),[4] and then to investigate market predictability at different trading frequencies. This is implemented via the use of the wavelet methodology, which reveals the inherent dynamics across different timescales. The "palette" of causality tests includes the linear Granger test (Granger, 1969) the Baek and

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[2] According to Stock and Watson (2003) the Great Moderation period initiated around the mid-1980s and lasted until the beginning of the 2000s. During that period, the growth variance of the G7 countries was considerably lower, from 50% to 80% in comparison to the pre- and the post –Great Moderation period.

[3] The transactions involving USD-Euro amount approximately to 40% of global trading (Bank for International Settlements (BIS), 2007).

[4] The prime motivation for choosing these particular exchange rates comes from them being the most liquid and widely traded currency pairs in the world. On the spot market, according to the Bank of International Settlements (BIS, 2007), the USD was involved in 86.3% of transactions, followed by the EUR (37.0%), the JPY (17.0%) and the GBP (15.0%). Volume percentages for all individual currencies should add up to 200%, as each transaction involves two currencies.