Journal of Financial Economics 94 (2009) 192–213

Contents lists available at ScienceDirect

Journal of Financial Economics

journal homepage: www.elsevier.com/locate/jfec

What drives volatility persistence in the foreign exchange market? ☆

David Berger [a], Alain Chaboud [b], Erik Hjalmarsson [b,*]

[a] Department of Economics, Yale University, P.O. Box 208281, New Haven, CT 06520, USA
[b] Division of International Finance, Federal Reserve Board, Mail Stop 20, Washington, DC 20551, USA

ARTICLE INFO

Article history:
Received 28 December 2007
Received in revised form
10 September 2008
Accepted 7 October 2008
Available online 15 July 2009

JEL classification:
C22
F31
G12

Keywords:
Volatility persistence
High-frequency data
Realized volatility
Long memory
Exchange rates

ABSTRACT

We propose a new empirical specification of volatility that links volatility to the information flow, measured as the order flow in the market, and to the price sensitivity to that information. The time-varying market sensitivity to information is estimated from high-frequency data, and movements in volatility can therefore be directly related to movements in order flow and market sensitivity. Empirically, the model explains a large share of the long-run variation in volatility. Importantly, the time variation in the market's sensitivity to information is at least as relevant in explaining the persistence of volatility as the rate of information arrival itself. This may be evidence of a link between changes over time in the aggregate behavior of market participants and the time-series properties of realized volatility.

Published by Elsevier B.V.

1. Introduction

The results of more than two decades of empirical volatility modeling all point towards the conclusion that the volatility of asset prices changes over time in a fairly persistent manner. However, there is still no clear agreement on why this is the case. The most common hypothesis is that the rate of information arrival affecting the price of an asset is itself persistent, perhaps because economic data relevant to the price are released in a clustered fashion or because analysis relevant to the price is produced in a clustered fashion. A less common explanation, which does not exclude the first one, is that variation over time in the sensitivity of market participants to information may also help explain the pattern of volatility persistence. This paper presents a simple, direct empirical test of the roles of both information arrival and market sensitivity in driving volatility persistence, using a unique high-frequency data set covering several years of global interdealer foreign exchange trading.

☆ We are extremely grateful to the referee, Torben Andersen, for greatly helping to improve the paper. Other helpful comments were provided by Federico Bandi, Tim Bollerslev, David Bowman, Mark Carey, Frank Diebold, Jon Faust, Joe Gagnon, Dale Henderson, Olan Henry, Lennart Hjalmarsson, Randi Hjalmarsson, Blake LeBaron, Mico Loretan, Richard Lyons, Michael Moore, Carol Osler, Andrew Patton, Dagfinn Rime, Joshua Rosenberg, Mark Seasholes, Clara Vega, Jon Wongswan, Jonathan Wright, Pär Österholm, and seminar participants at the Federal Reserve Board, the Federal Reserve Bank of New York, the IMF, the North American Summer Meeting of the Econometric Society at Duke University, the European Summer Meeting of the Econometric Society in Budapest, and the Central Bank Market Microstructure Conference in Budapest. The views in this paper are solely the responsibility of the authors and should not be interpreted as reflecting the views of the Board of Governors of the Federal Reserve System or of any other person associated with the Federal Reserve System.

* Corresponding author. Tel.: +1 202 452 2426; fax: +1 202 263 4850.
E-mail address: erik.hjalmarsson@frb.gov (E. Hjalmarsson).

0304-405X/$ - see front matter Published by Elsevier B.V.
doi:10.1016/j.jfineco.2008.10.006

Much of the previous research on factors driving volatility derives from studies of 'mixture of distributions' models proposed by Clark (1973), Tauchen and Pitts (1983), and Andersen (1996), among others, where volatility and trading volume are jointly directed by the process of information arrival. Thus, in these models, persistence in the information arrival process generates persistence in volatility and trading volume. In practice, however, the estimated persistence of volatility in such models has typically been found to be well below that of univariate time-series models of volatility. Liesenfeld (2001), extending the previous mixture models, allows for volume and volatility to be driven not only by a latent information arrival process but also by an additional latent process that governs the *impact* of information on prices. He shows that such a model, where the dynamics of volatility are associated with both the rate of information arrival and the time-varying sensitivity to information, can capture much more of the persistence in volatility.

Though our paper is inspired by the result of Liesenfeld (2001), it takes a very different approach from previous work on the study of volatility persistence. In particular, we draw upon recent findings on the relationship between returns and order flow. This relationship, which has been studied extensively in the foreign exchange market in the past few years (e.g., Evans and Lyons, 2002, 2004), has been found to account for a substantial share of observed movements in exchange rates. The main thrust of the current paper is to show that there are large and persistent variations over time in the relationship between returns and order flow, and to study how these variations, along with variations in the order flow itself, are linked to the time-series behavior of volatility.

Evans and Lyons and other authors have argued that the contemporaneous explanatory power of order flow for exchange rate movements derives in great part from the fact that information relevant to the price is transmitted to the market through order flow, a point previously demonstrated by Hasbrouck (1991) for the stock market. To the extent that order flow represents information, our empirical specification therefore allows us to decompose the factors affecting volatility into two time-varying components: the flow of information itself and the sensitivity of the market to that information. It should be stressed, however, that our results on the role of market sensitivity in driving volatility do not depend upon the interpretation of order flow as information, although we focus on that interpretation.

The empirical analysis is conducted using a unique data set that represents a majority of global interdealer trading in the spot euro-dollar exchange rate at the one-minute frequency over a period of several years. Importantly, the frequency and the content of the data permit us to estimate a time-varying market sensitivity parameter at the daily frequency. We can therefore treat the market sensitivity as an observed variable, along with order flow and realized volatility. This allows us to analyze directly the interactions of the time-series properties of these three variables, without relying on latent variables.

Focusing on the fact that volatility is a slow-moving and fairly persistent process that is well described by a long-memory model, we frame the empirical analysis as a test of fractional cointegration. This provides a test of how closely the long-run movements in volatility are linked to the long-run swings in order flow and market sensitivity. This empirical setup offers several advantages. By explicitly modeling the persistence in the data, it becomes possible to evaluate the degree to which the persistence in the dependent variable is captured by movements in the right-hand side variables. In particular, the long-memory framework provides a concise summary statistic of the degree of persistence and thus easily enables comparison between the persistence in the original data and in the cointegration residuals. In addition, by testing for (fractional) cointegration, we guard against the risk of spurious regression, a possibility given the persistent nature of the data. Finally, the estimation methods employed are robust to potential endogeneity in the regressors, which is clearly a concern in a standard ordinary least squares (OLS) analysis of these time series.

Overall, the empirical results are very strong. We show that a very large share of the persistence in volatility can be explained by variations in the market's sensitivity to order flow and variations in the order flow itself. Thus, if one interprets order flow as information, the results show that volatility persistence can be linked to both the persistence of the market's sensitivity to new information and the persistence of the information flow itself. Furthermore, the empirical analysis clearly shows that the variations in market sensitivity play at least as large a role in driving volatility persistence as the variations in the flow of information. This finding may point to an important link between changes over time in the aggregate behavior of market participants and the times-series properties of volatility. From an econometric point of view, we observe that the measured persistence in the information flow is not large enough to capture the persistence in volatility, whereas the persistence of the sensitivity parameter is very similar to that of volatility. In fact, our results show that the information flow appears more closely linked to the shorter-, or medium-term, behavior of volatility, whereas the market's sensitivity to information is more closely related to the longer-run behavior of volatility.[1]

The paper proceeds as follows. Section 2 introduces the high-frequency exchange rate data used in our analysis. Section 3 first derives our empirical specification, addressing its motivation, its empirical validity, and the constructed variables that we use in our estimations. It then presents some preliminary OLS analysis of the contemporaneous relationships between our constructed variables. Section 4 outlines the fractional integration and cointegration methodology used in the remainder of the paper. Section 5 presents our main estimation results, and Section 6 presents some additional extensions and robustness results. Section 7 studies the interaction

[1] Liesenfeld (2001) finds a similar result using his mixture of distributions model with a latent market sensitivity variable.