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Housewives of Tokyo versus the gnomes of Zurich: Measuring price discovery in sequential markets ☆

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Abstract

This paper presents two methods to measure market-specific contributions to price discovery in non-overlapping sequential markets: one is a non-parametric approach using high-frequency data and the other is a structural VAR model based on open-to-close returns. The methods complement the existing methodologies for comparing price discovery in parallel markets. Using these methods, we estimate the information shares of four sequential markets for the trading of AUD, JPY, EUR, and GBP against USD over an eight-year period. We find that price discovery in the foreign exchange markets are still dominated by Europe and the United States, particularly the London–New York overlapping trading hours. Asia is losing information shares to Europe in the trading of AUD and JPY. The significance of the "housewives of Tokyo" in currency trading may have been overstated.

Introduction

The above speech, given at the Brookings Institution in Washington on July 2, 2007, created the metaphorical "Mrs. Watanabe," whose currency trading and market impact captured the imagination of financial press. "Now, a new beast is roiling markets — Mrs. Watanabe, or Japan's archetypal housewife," says the *Financial Times* on the next day. "On her shoulders may lie responsibility for some of the stability of the global financial system," according to The Economist (August 16, 2007). The speech by Dr. Nishimura, along with the press commentaries, suggests that retail investors in Japan have significant market impact in currency trading. However, Tokyo is not a leading hub for currency trading, not even for yen-related transactions.[3] Its share of currency trading has been declining relative to markets elsewhere. If indeed the "housewives of Tokyo" are replacing the "gnomes of Zurich" and winning against futures traders in Chicago, it would suggest that trading in Tokyo has greater price impact than trading in Europe and North America. Is Tokyo a leading information hub for currency trading, particularly for the yen? How does one measure the

significance of Tokyo trading to the pricing of the Japanese yen relative to trading in markets in Europe and North America?

This paper aims to address these questions. It proposes and compares two approaches to estimate the contribution of a particular market to the price discovery of an asset traded in multiple markets. The global financial liberalization has resulted in more assets than ever before being traded in multiple markets around the world. As companies and economies become more exposed to global risk factors, knowing where price discovery occurs often sheds light on what factors affect asset prices. A cross-market comparison of price discovery provides an estimate of the distribution of information and information-based trading for the underlying asset. A market's contribution to price discovery reflects its efficiency in collecting and analyzing information, the quality of its regulation and microstructure, as well as its liquidity, which are important for attracting informed investors. With changes in global economic conditions and trading technology, the significance of a market may change over time. The traditional link between an asset, e.g., the Australian dollar and a particular market, e.g., Sydney, may be weakening. While officials in Japan are concerned with maintaining the global status of the Japanese financial markets, markets in Shanghai are getting greater global attention. Understanding what changes have taken place in the global pecking order is necessarily the first step in understanding what factors are responsible for such changes.

In this paper we measure price discovery in multiple markets that are sequential in time and non-overlapping (e.g., Tokyo and London). The case of parallel markets where trading takes place simultaneously in different venues (e.g., the NYSE and the NASDAQ) was first examined in the seminal study by Hasbrouck (1995). The information share proposed by Hasbrouck (1995) measures the contribution of a particular market to the changes in the efficient price of an asset. An alternative approach taken up by Booth, So, and Tse (1999), Chu, Hsieh, and Tse (1999), and Harris, McInish, and Wood (2002), uses the permanent-transitory decomposition of Gonzalo and Granger (1995). Both approaches have been adopted by numerous studies of price discovery between parallel markets (e.g., spot versus derivative trading, floor versus electronic trading). Cross-market comparisons of price discovery have spawned into "a mid-sized cottage industry" (Lehmann, 2002). A special issue of the *Journal of Financial Markets* in 2002 was devoted to the comparison between the two approaches. Pascual, Pascual-Fuster, and Climent (2006) expand the Hasbrouck model to distinguish trade-related versus trade-unrelated information shocks. New applications of the Hasbrouck and the Gonzalo-Granger models have continued to flourish.[4]

In parallel markets, price discovery occurs simultaneously in multiple venues; therefore it is difficult to achieve a clean separation of price innovations from different markets. This is well recognized in the literature (e.g., Lehmann, 2002). Recently Yan and Zivot (2010) use a structural cointegrated VAR to give new insights to the comparison between the Hasbrouck and Gonzalo-Granger models. Yan and Zivot (2007) propose to use the cumulative impulse responses from the structural cointegrated VAR to better capture the dynamics of price discovery.

Because the existing models are designed only for parallel markets, international comparisons of price discovery are often limited to one or two hours of overlapping trading time (e.g., Hupperets and Menkveld, 2002, Grammig et al., 2005, Pascual et al., 2006). In most cases, the closing of the home market overlaps with the opening of the overseas market, often the NYSE. The small overlapping hours may lead to bias against the newly-opened market as the newly-arrived traders learn from past price movements (see Hsieh and Kleidon, 1996). Menkveld, Koopman, and Lucas (2007) develop a state-space model that takes into account prices from non-overlapping trading periods for partially overlapping markets. Currently there is no model designed for comparing price discovery across non-overlapping markets (e.g., Tokyo vs. London or Shanghai vs. New York). Studies of non-overlapping markets (e.g., Lieberman et al., 1999, Agarwal et al.,

2007) focus on Granger causality between the prices without measuring their contributions to the efficient price.

We propose two approaches to measure price discovery in sequential non-overlapping markets. The basic logic behind the two approaches is the same as the Hasbrouck model: Information flow is measured by the variation in the efficient price of an asset. Changes in the efficient price are identified as the random-walk component of the observed returns. The information share of a particular market is its share in the total variance of the efficient price in a trading day. The two approaches differ in how the variance of the efficient price is estimated. The first approach is based on the recent advances in estimating the integrated variance using high-frequency observations. We use the two-scales (TS) estimator of Zhang, Mykland, and Aït-Sahalia (2005), which is a consistent estimator of the integrated variance. The variance of the efficient price is estimated as the mean of the TS estimator. In addition to the information share, the ratio of the TS estimator to the realized variance provides a measure for the pricing efficiency of a market. Our second approach is based on a structural vector autoregressive (VAR) model for the open-to-close returns of sequential markets. This is particularly useful when intraday prices are not available, or when measuring information flows during non-trading periods (e.g., overnight). Studies have shown significant information flow during non-trading periods. Our measure of the information contribution of each market is based on the market-specific shocks and has a clean interpretation. The structural VAR model has several advantages: it is very easy to implement, its data requirement is not onerous, and the empirical results do not depend on intraday sampling frequency and the noise-filtering method used. The drawback of the structural VAR is that the intraday observations are not fully exploited for estimating the variance of the efficient price change. In our sample, the estimated information shares from the structural VAR are similar to those from realized variance. As discussed in Section 3, combining our methods with those for parallel markets allows researchers to study the general case of partially overlapping markets.

Our methods are applied to the foreign exchange markets, which trade continuously around the clock. By estimating the information shares across markets and time zones, we provide new evidence on exchange rate price discovery. There is indirect evidence that some markets are more important than others in currency trading. Ito, Lyons, and Melvin (1998) and Covrig and Melvin (2002) provide evidence of private information in currency trading and suggest that Tokyo may know more about the yen than other markets. However the findings are disputed by Andersen, Bollerslev, and Das (2001). We compare price discovery across global markets for AUD, JPY, EUR, and GBP, all against USD, for an eight-year period from January 1996 to December 2003. These are the top-four currency pairs in trading value, representing 58% of global currency trading (Bank for International Settlements (BIS), 2007). A 24-hour day is divided into four sequential markets (see Table 1): “Asia,” “Europe,” the overlap between London and New York City labeled as “London+NYC,” and “U.S.,” which covers trading in the Americas. The information shares of these markets are estimated using realized variance, as well as the structural VAR model. Sub-period analyses reveal changes in the contribution of each market over the eight years. The findings are summarized below:

- “Europe” and “London+NYC” have the highest pricing efficiency: over 90% of the price variations are changes in the efficient price. Their combined information shares are 40–42% for AUD and JPY and 51–53% for EUR and GBP. “Asia” has the lowest pricing efficiency among the four markets. Its information shares are 28–33% for AUD and JPY and 16–17% for EUR and GBP. “U.S.” takes up the remaining shares.

- Over the sample period, price discovery appears to become more concentrated in “Europe,” particularly in the “London+NYC” trading hours. “Asia” lost shares in Asian currencies while “U.S.” remained stable. For JPY, the information share of “Asia” declined from 33% in 1996–1999 to 28% in 2000–2003. “Europe” increased its share from 28% to 31% and that of “London+NYC” rose from 12% to 15%. The findings suggest

that Tokyo is not a leading information hub for JPY. The significance of "Mrs. Watanabe" may have been overstated.

- The two-hour "London+NYC" period is highly significant for currency trading. It has the highest per-hour information shares for all currencies. It gained information shares in all four currencies over the sample period.

- Different measures of information shares give similar estimates of the significance of a market. However the information share of a market can be very different from its share of trading volume. For example, "Asia" accounts for over half of AUD trading but less than one-third of AUD information share. In general, the share of the trading volume of the home market overstates its information share.

Although we do not examine what affects a market's information share, evidence from microstructure studies of the foreign exchange markets offers some clues. Since the trading platform is the same, the difference between markets is in the number and characteristics of market participants. Studies have shown that order flows are the critical link between exchange rate changes and economic fundamentals (Evans and Lyons, 2002a, Evans and Lyons, 2005, Evans and Lyons, 2007, Evans and Lyons, 2008); order flows from financial institutions have greater information content than other investors (Bjonnes et al., 2005, Carpenter and Wang, 2007); and there are cross-market information flows between currencies (Evans and Lyons, 2002b, Yan and Zivot, 2007). Therefore a market's information share depends on the quantity and the quality of its order flows. Such order flows tend to come from financial institutions with a large client base and substantial research capacity.

The paper is organized as follows: Section 2 presents the two approaches for measuring price discovery in sequential markets. Section 3 explains the data and trading statistics in the foreign exchange markets. The estimation and empirical findings in the currency markets are discussed in Section 4. Section 5 is a brief summary.

Section snippets

Measuring price discovery in sequential markets

Consider a single asset traded in two adjoining and non-overlapping markets during a 24-hour trading day. The scenario is depicted in Fig. 1: market 1 opens at the beginning of day t and closes at the point when market 2 opens, while market 2 closes at the beginning of day t+1. As discussed shortly, the setup can be easily modified to allow overlapping markets or non-trading periods. The closing prices of markets 1 and 2 are $p_{1,t}$ and $p_{2,t}$, respectively. The end-of-day price is $p_t \equiv p_{2,t}$. All…

Global currency markets and data summary

The global currency markets can be treated as the sequential markets described in Section 2. A common asset, e.g. the Japanese yen, is traded 24 hours a day across Asia, Europe, and the United States time zones. The trading platform is identical across all markets. While the determinants of currency values are not well understood,[15]…

Information shares in currency trading

This section reports the empirical estimation of the information shares of the four sequential markets: “Asia”, “Europe”, “London+NYC”, and “U.S.”. The first two sub-sections report the estimated information shares based on realized volatility and the structural VAR model, respectively. We then present evidence on the information shares of per-hour trading and the changes of information shares over the eight-year sample period.…

Final remarks

Two simple methods for comparing price discovery in sequential markets are introduced and applied to the 24-hour foreign exchange trading. We present new evidence on the information shares across markets in different time zones, and how the information shares have changed over the eight-year sample period. Our model for sequential markets can be used in conjunction with models for parallel markets to compare price discovery in partially overlapping markets. It can also be used to measure the…

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