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# The probability of informed trading measured with price impact, price reversal, and volatility

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ABSTRACT

Contemporaneous and positive correlation between order flow and exchange rate is a stylized fact. I postulate that the order flow driven by informed trading has a significant price impact. I also do that little price reversal occurs in the subsequent period. The Markov-switching model provides probabilities of a significant price impact and little price reversal. I apply these probabilities to measure the probability of informed trading. The measure explains a greater share of the random walk component of price compared to other measures offered by previous studies.

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## 1. Introduction

An established market maker does not play a crucial price discovery role in an order-driven market, whereas the opposite is true in a quote-driven market. However, the literature concerning an order-driven market assumes a hypothetical market maker. This literature then uses the measure of probability of informed trading (henceforth PIN) approximately[1]. PIN's theoretical background originates from a quote-driven market with an established market maker. To overcome this theoretical inconsistency in an order-driven market, this article proposes an alternative intraday measure for PIN. My measure does not assume the structure of a quote-driven market. My measure is also available for high-frequency study. Importantly, it is beneficial for researchers in an order-driven and quote-driven market at high frequencies. It simply assumes that the order flow from informed trading has a persistent effect on an asset price, a reasonable assumption for both markets.

The theory of PIN originates from Easley and O'Hara (1992). The theory assumes a competitive risk-neutral market maker. The market maker observes incoming orders and uses Bayesian inference to discover private information conveyed by these orders. The market maker has continuous buy (sell) orders from market participants. The market maker infers the arrival of good (bad) news and revises quote in an upward (downward) direction. Assuming that uninformed (liquidity) traders buy and sell randomly, PIN considers that informed trading causes abnormal order imbalance. PIN is derived using a sophisticated theory, and a number of empirical studies use PIN as a measure of informed trading. Some debate exists concerning the validity of PIN and its theoretical and practical limitations. The following section provides a brief summary of the PIN debate.

First, PIN assumes that (good or bad) information arrives at the maximum rate of once per unit of data frequency. For relatively small stocks, transactions are infrequent, and a daily basis is chosen as a data frequency to estimate PIN. This is inconsistent with recent microstructure analyses. They assume intraday arrival of and short-lived information, particularly

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[1] Throughout this paper, PIN refers to the probability of information trade developed by Easley et al. (1996).

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with the active trades of EUR/USD and USD/JPY[2]. To overcome this issue, Owens and Steigerwald (2005) and Easley et al. (2008) develop a model that can accommodate intraday changes in the arrival rate of information. Owens and Steigerwald (2005) assume that the process of the arrival rate of information follows the Markov model and estimate a half-hour PIN. Easley et al. (2008) propose a daily varying PIN. They have a generalized autoregressive specification on arrival rates of information, uninformed, and informed traders. Kaul et al. (2008) show that absolute order imbalance is equivalent to PIN under a certain condition. This imbalance is easy to calculate without numerical maximization at high-frequency levels. Chang et al. (2014) find that trades driven by contrarian are positively related to firm-specific return. Therefore, the authors recommend the use of the ratio of contrarian's trade as a dynamic intraday version of PIN. This version requires no numerical maximization and is easy to calculate.

Second, the empirical model of PIN assumes the Poisson process for the arrivals of uninformed and informed traders. This assumption leads researchers to manage overflow problems in calculating exponential numbers with relatively large numbers of buy and sell. To avoid this overflow problem and estimate unbiased PIN, Yan and Zhang (2012) recommend estimating the factorized likelihood function developed by Lin and Ke (2011). Jackson (2013) proposes a simple procedure to scale large numbers of buy and sell for actively traded stocks.

Third, the PIN theory assumes that a market maker discovers information relevant to an asset price in a quote-driven market. This assumption forces researchers to use a hypothetical market maker in an order-driven market (e.g., Gençay and Gradojevic, 2013; Kubota and Takehara, 2009). Gençay and Gradojevic (2013) estimate the intraday PIN for the EUR/USD, the USD/JPY, and the USD/CHF rates traded via the Electronic Broking Service (henceforth EBS). EBS is an electronic, order-driven market without established market makers. In this market, hypothetical market makers observe transactions on an EBS monitor and post their quotes into a limit order book. Kubota and Takehara (2009) adopt the same assumption as Gençay and Gradojevic (2013) and estimate PIN in the electronic, order-driven market of the Tokyo Stock Exchange.

Finally, certain empirical literature casts doubt on PIN's ability to function as an effective measure of informed trading. Akay et al. (2012) find that the PIN for a T-bill market, with less information asymmetry than stock markets, is substantially higher than the PIN for equities. This finding then leads the authors to conclude that PIN simply identifies trade clusters (abnormal trading) driven by illiquidity factors. Duarte and Young (2009) adjust PIN by introducing liquidity transaction shocks. They conclude that the original PIN is the result of liquidity shocks but not informed trading.

Recently, electronic, order-driven markets have become the main markets for exchange rate transactions. The popularity of electronic broking enhances the availability of high-frequency data in exchange rate transactions. This recent research stream has motivated researchers to conduct high-frequency analysis. Researchers also explore the price discovery process in a foreign exchange (FX) market using high-frequency analysis. However, PIN may not be a proximate measure for informed trading to examine an order-driven FX market at high frequencies.

This study proposes an alternative measure for informed trading. The measure does not assume an apparent established market maker. It focuses on the relationship between order flow and exchange rates. To detect informed trading, I focus on order flows driven by informed trading. I assume that they have significant contemporaneous price impact and little price reversal in the subsequent period. The order flows, which the Markov-switching model detects, have persistent effects on an exchange rate.

The recent research stream concerning FX markets focuses on the role of order flow in price discovery (e.g., Lyons, 2001). This stream suggests that order flows convey relevant information that an FX rate will discover. This finding has motivated the proposal in this paper of a measure of informed trading. This paper proposes the identification of order flow driven by informed trading. Nyholm (2003) and Jiang and Lo (2014) have the same motivation. The authors use the regime-switching model to detect the regime of informed trading. They postulate that the order flows driven by informed trading have substantial price impact on a return. The authors then consider the regime of that price impact as informed trading. I also consider price impact and, notably, the persistency of that impact with subsequent price reversal. My empirical results show that my proposed measure possibly explains a greater share of the random walk component of an FX rate than measures from previous studies. This empirical evidence indicates the validity of my measure to the detection of informed trading.

The remainder of this paper is organized as follows. The next section explains EBS data and provides a brief survey on the relationship between an FX rate and order flows. The section explains the new measure for informed trading. Section 3 presents empirical results and checks robustness. I also compare the proposed measure to PIN in Section 3. The last section presents the conclusions of the paper.

## 2. Data and the new measure for informed trading

### 2.1. Data

I obtain the EBS Data Mine 1.0 from ICAP, which provides the electronic trading platform. The EBS platform provides an order-driven market from an electronic limited order book with no designated market maker. The sample period is from October 1, 2014 to September 30, 2015. This sample includes the transactions for approximately one year.

[2] Easley et al. (2010) note "we also suspect that the microstructure model provides a better description of the information environment for smaller stocks."

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