A dynamic intraday measure of the probability of informed trading and firm-specific return variation

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ABSTRACT

A central question in financial economics is how private information is incorporated into asset prices. A common method of measuring private information is the PIN measure, which uses statistical estimation of a sequential trade model of the trading process to estimate the probability of informed trading. A notable limiting feature of PIN is that one must aggregate very fine intraday data over very long macro horizons in order to estimate it. In this paper, our aim is to develop and implement a dynamic intraday measure of the probability of informed trading that circumvents this aggregation issue and allows for the measurement of information based trading activity at much higher frequencies. We then apply our dynamic intraday measure of the probability of informed trading to examine the relationship between private information and firm-specific return variation.

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1. Introduction

A central question in financial economics is related to the role of information in markets and the process by which information is incorporated into asset prices. The market microstructure literature identifies two broad investor types: informed traders, who buy and sell assets based on information they possess regarding the asset's true future intrinsic value, and liquidity (or noise) traders, who trade for purposes unrelated to information such as meeting liquidity needs. Empirically, however, while detailed transaction level data are available at the intraday level (i.e., trade-by-trade basis), these data do not indicate whether a particular trade is initiated by an individual who is informed or not. To make this determination, researchers must commonly infer from the data whether trades are more likely information or liquidity based.

One of the most common and widely accepted methods of doing this is the PIN measure of Easley et al. (1997a,b) and Easley et al. (2002), which estimates the probability of informed trading based on a sequential trade model drawn from Glosten and Milgrom (1985) and Easley and O'Hara (1987). With a measure of information based trading in hand, researches have extensively applied PIN to study the effect of informed trading in a broad range of areas in finance, including stock price informativeness, corporate governance and investment decisions, stock market volatility, and insider trading, just to name a few.

However, the traditional PIN measure has some well known limiting features. Most notably, in order to estimate it one must aggregate very fine intraday data, which occur at approximately five-minute intervals within the trading day, across multiple days

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(Easley et al., 1997a,b). The resulting estimate measures informed trading over a very long macro horizon — typically from one month to one year. Arguably, the variation and information content of intraday trades is diluted, or possibly even lost, when combining over such long time periods, especially in modern financial markets where information is short-lived and traders act with increasing alacrity. Indeed, with regard to the necessity of using many days in their maximum likelihood procedure, Easley et al. (1997a) concede the tradeoff between estimation accuracy and economic reasonableness: "[w]hat is also apparent, however, is that while it may be sensible to use large sample methods to estimate [certain parameters in the PIN model], it is less so for [other parameters in the model]. The presumed stationarity of information is unlikely to be true over a long sample period, dictating a natural limit to the number of days we can sensibly employ." As such, horizons of multiple months, or up to one year in the case of Easley et al. (2002), might seem to push the envelope of such sensibility.

In addition, over such long macro horizons it is likely that the actual impact of short-lived private information may become diluted or masked by other factors. For example, Duarte and Young (2009) argue and find that PIN can be decomposed into two further components: one that represents private information, as originally postulated, but another component that is a proxy for market illiquidity (i.e., disruptions in the supply and demand conditions in stock markets) that is unrelated to information. Since market illiquidity is certainly a more long-lived phenomenon than private information, this is suggestive that Duarte and Young's finding may be an artifact of the aggregation process.

The first aim of our paper is to develop and implement a dynamic intraday version of PIN, which we refer to as DPIN, that circumvents the aggregation issue described above and allows us to estimate the probability of informed trading at much finer frequencies — specifically, at 15-minute intervals throughout the trading day. Since such frequencies are more in line with the speed at which traders react to and digest information in modern financial markets, our dynamic DPIN measure may be better suited to more accurately capture information based trading activity at higher frequencies, even within the trading day.

Our method for constructing DPIN comes from an extension of the approach of Avramov et al. (2006), which is based on the trading model of Campbell et al. (1993) and used to study the effect of informed *selling* on daily stock price volatility. The contribution of our paper in this respect is to recognize that this approach can be further employed to derive a dynamic intraday measure of the probability of informed trading, essentially by calculating the proportion of trades that are classified as information based over a given time interval. The DPIN measure has the advantage of being dynamic and flexible — it can be aggregated over many intervals to make comparisons with existing macro-horizon models, yet it is also capable of capturing cross-sectional and time-series variation in the probability of informed trading at much higher daily and intraday frequencies. Another advantage is that the DPIN measure does not require any form of numerical optimization for its estimation and thus is relatively simple and quick to compute from the transactions data, thus providing a more straightforward and less time consuming alternative method for dealing with tremendously large datasets involving intraday transactions.

Upon specifying several versions of the DPIN measure, we find numerical estimates that are generally consistent with existing measures for the probability of informed trading. When aggregated to similarly long horizons as the PIN in Easley et al. (2002), several of our DPIN measures are remarkably close in terms of location, spread, and skewness when combining across firms and years. Another version of our DPIN measure turns out to be quite close numerically to that of Nyholm (2002), who also attempts to measure the probability of informed trading at the transaction level. We take these results as evidence that our proposed DPIN measures are not too far off the mark and conform to the range of previous estimates found in the literature. However, a distinguishing feature of our analysis is that we are also able to disaggregate the time horizon, allowing an examination of the intraday pattern of informed trading, as well as how this pattern has evolved over time. As we will discuss, such results provide new empirical evidence for existing microstructure theories on the intraday behavior of information based trading activity.

With a new dynamic intraday measure of the probability of informed trading in hand, the second aim of the paper is to apply this measure to study an open question in finance regarding the role of private information and a particular aspect of asset returns, namely firm-specific return variation, or price non-synchronicity. Roll (1988) finds that firm-specific stock price movements are generally not associated with identifiable news releases and thus surmised that private information might play a crucial role in explaining such movements. Ever since Roll's conjecture, researchers have taken (for granted) the notion that firm specific-return variation might be caused by private information. For example, Morck et al. (2000), Durnev et al. (2003, 2004), and Chen et al. (2007) use firm-specific return variation as a proxy for stock price informativeness to study an array of issues at the intersection of private information, price formation, corporate earnings forecasts, capital budgeting, and investment policy. Tellingly, each of these papers acknowledges that their respective analyses rest upon the validity of the notion that price non-synchronicity is indeed caused by private information, and ultimately only provide indirect and circumstantial evidence of their possible link. Indeed, Durnev et al. (2004) state further the caveat that the "conceptual arguments and empirical studies [cited above] constitute a *subtle case* [emphasis added] for accepting firm-specific return variation as a proxy for stock price informativeness…(p.66)."

While many of these indirect arguments are conceptually appealing and point convincingly to a relationship between private information and price non-synchronicity, very few studies have directly investigated the relationship between the two variables, especially at higher frequencies. Thus, as an application of our dynamic intraday measure of informed trading, we examine the empirical link between private information and firm-specific return variation to provide more in-depth and direct evidence on the validity of Roll's (1988) conjecture.

The rest of the paper is organized as follows. Section 2 describes the data used in the study. In Section 3, we construct and compute the various DPIN measures and compare them to previous measures of informed trading in the literature. We also examine their intraday properties and implications for the theoretical microstructure literature in this regard. Section 4 uses the DPIN measures to study the relationship between price non-synchronicity and private information, providing direct evidence for Roll's (1988) conjecture. Section 5 concludes.