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Price pressures ☆

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ABSTRACT

We study price pressures, i.e., deviations from the efficient price due to risk-averse intermediaries supplying liquidity to asynchronously arriving investors. Empirically, New York Stock Exchange intermediary data reveals economically large price pressures, 0.49% on average with a half life of 0.92 days. Theoretically, a simple dynamic inventory model captures an intermediary's use of price pressure to mean-revert inventory. She trades off revenue loss due to price pressure against price risk associated with staying in a nonzero inventory state. The closed-form solution identifies the intermediary's risk aversion and the investors' private value distribution from the observed time series patterns of prices and inventories. These parameters imply a relative social cost due to price pressure, a deviation from constrained Pareto efficiency, of approximately 10% of the cost of immediacy.

1. Introduction

The cost of trading large quantities quickly, often referred to as liquidity, plays a fundamental role in facilitating risk sharing and allocating resources through securities markets. A market might turn illiquid through two main channels. Informational asymmetry makes counterparties charge a permanent price impact to protect against losses due to information-motivated traders (e.g., Glosten and Milgrom, 1985). In addition, a natural counterparty might not yet be in the market and a risk-averse intermediary charges a price impact for temporarily holding the position (e.g., Grossman and Miller, 1988). This price impact is transitory as the price rebounds once the natural counterparty arrives, allowing the intermediary to liquidate its initial position. These transitory price effects or price pressures are the focus of this study.

This paper generates systematic evidence on the price pressure channel and interprets it based on a structural

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model. The empirical challenge is to disentangle price pressure effects associated with an intermediary's trading from informational effects. A state space model decomposes price changes into two components: a permanent change due to information and a transitory change potentially due to price pressure. The empirical model relates the permanent changes to surprise order flow and the transitory changes to the intermediary's inventory. Moreover, the empirical state space model turns out to be the solution of a simple structural model in which a representative intermediary solves a dynamic inventory control problem. Thus, the empirical estimates identify deep parameters such as the intermediary's risk aversion and investors' private value distribution for the assets they trade.

Several reasons can be cited for why the state space approach is preferable to other approaches such as an autoregressive moving average (ARIMA) model (e.g., Hasbrouck, 1991a,b) or the generalized method of moments (GMM). First, maximum likelihood estimation is asymptotically unbiased and efficient. Second, the Kalman filter used in the estimation ensures maximum efficiency in dealing with missing values; i.e., it accounts for level series changes across periods with missing observations. Standard approaches based on the differenced series discard such information. This is particularly beneficial for high-frequency data on inactively traded securities. Third, after estimation, the Kalman smoother (a backward recursion) enables the decomposition of any realized price change into a permanent part and a transitory part conditional on all observations, i.e., past, current, and future observations. Therefore, the decomposition benefits from peering into the future. Durbin and Koopman (2012) provide an in-depth discussion on the use of state space models in economics. Hasbrouck (1999) applies the state-space approach to the intraday dynamics of discrete bid and ask quotes.

The empirical estimates show economically large and persistent price pressures. The state space model is estimated for 697 stocks based on daily prices and inventory positions of NYSE intermediaries from 1994 through 2005. The average size of price pressure is 49 basis points with a half life of 0.92 days. Substantial cross-sectional variation exists. Price pressure for the quintile of largest stocks is 17 basis points with a half life of 0.54 days. For the smallest-stocks quintile, it is 118 basis points with a half life of 2.11 days. These price pressures are roughly the size of the (effective) bid–ask spread.

The state space estimates also yield a novel empirical measure of liquidity: the price pressure an intermediary charges per unit of inventory. This marginal price pressure is the price elasticity of liquidity demand and is an alternative to the standard bid–ask spread measure. Institutional investors in particular often care more about the marginal pressure than the spread. They typically split large orders into small pieces sent to the market sequentially. The cumulative impact of that order i.e., the extent to which their trading drives the price away from the efficient price as the order executes, is typically much larger than the half-spread paid on each individual order. Marginal price pressure as a liquidity measure instead of the spread is in the tradition of earlier work by Stoll (1978), Grossman and Miller (1988), Campbell, Grossman, and Wang (1993), and Pastor and Stambaugh (2003).[1]

Small stocks are much less liquid than large stocks based on marginal pressure than based on the spread. The marginal price pressure is 0.02 basis points per one thousand dollars of idiosyncratic inventory position for the (quintile of) largest stocks and 0.98 basis points for the smallest stocks. The (half-) spread for these two sets of stocks is 8.41 and 46.12 basis points, respectively, implying the largest stocks are 49 times more illiquid when measured by marginal pressure but only five times more illiquid when measured by spread. The analysis is based on idiosyncratic inventory because systematic inventory risk can easily be hedged through offsetting positions in index futures or exchange traded funds.

A simple recursive structural model in the spirit of Ho and Stoll (1981) helps to further understanding of the average size of price pressure, its duration, and the level of marginal pressure. The model studies a risk-averse intermediary who uses price pressure to manage risk though mean-reverting her inventory. She equates the size of the subsidy she pays to speed up mean-reversion, i.e., the price pressure, to the utility cost of one more time unit of price risk on her nonzero position. This pecuniary amount equated to a utility cost facilitates empirical identification of the model's deep parameters. Observed price pressure together with the price risk on the intermediary's inventory identifies her risk aversion. The speed of mean-reversion given the level of price pressure identifies investors' private value distribution as it captures how price pressure impacts investors' buying and selling. If the private distribution is relatively flat (inelastic), then not many buyers are replaced by sellers and the net demand response to price pressure is small. This intuition is formalized in the stochastic inventory control problem and its closed-form solution.

The model's solution along with the time series properties of price pressure generates a rich economic perspective. The intermediary's relative risk aversion is 3.96. The uniform distribution assumed for private values ranges from -185 to $+185$ basis points. The model-implied (half-) spread that makes the intermediary indifferent between participating or not ranges from 7.63 basis points for the largest stocks to 87.41 basis points for the smallest stocks. This range estimate is based entirely on inventory dynamics and price pressure estimates. It is, therefore, comforting that it is the same order of magnitude as the observed half-spread range of 8.41–46.12 basis points.

The model also provides insight into potential investor welfare loss due to asynchronous arrivals and risk-averse intermediation. The intermediary internalizes the price pressure as the cost of risk management (inventory reduction). This cost, however, overestimates the extent to which private value is lost as it is based on the differential valuation of the marginal seller who is substituted by the marginal buyer. A social planner cares about the average

[1] Grossman and Miller (1988, p. 630) criticize not only the bid–ask spread as a liquidity measure but also the liquidity ratio, defined as the ratio of average dollar volume to the average price change. Its reciprocal, the illiquidity ratio, is subject to the same critique.