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# Insider trading and risk aversion☆

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## Abstract

This paper is a continuous time version of Holden and Subrahmanyam (Economics Letters 44 (1994) 181). The paper extends Kyle (Econometrica 53 (1985) 1315) by introducing risk aversion on the side of the monopolist informed trader and allows for the liquidity traders instantaneous demand to depend on cost of trading, as well as on the risk of the stock. The main result of the paper is that, in equilibrium, the price pressure decreases with time regardless of the elasticity of the liquidity demand function. © 2002 Elsevier Science B.V. All rights reserved.

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## 1. Introduction

Kyle (1985) models a sequential batch market with a strategic, informed trader who submits market orders to competitive, risk-neutral market makers. His orders are aggregated with liquidity traders' orders, so the market makers observe only the cumulative market order imbalance. This anonymity of trade allows the informed trader to exploit his information. The market makers offset their losses to the informed trader by charging the liquidity traders a premium for immediacy. This premium is measured by the price pressure, $\lambda$, or the market depth, which is the reciprocal of $\lambda$.

The informed trader, in the Kyle model, runs the risk that profitable trading opportunities will be lost as the liquidity traders shift prices. This risk is ignored

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when the informed trader is risk neutral. Consequently, as was pointed out by Kyle (1985), a time varying price pressure would allow the informed trader to use profitable destabilization schemes. In contrast, the risk liquidity traders impose on the informed trader matters when the informed trader is risk averse. This risk motivates the risk-averse informed trader to trade more intensely at the early stages, thus releasing more information than a risk neutral informed trader would. Early release of information reduces the information asymmetry and allows the market makers to decrease $\lambda$ with time as they become more confident about the prices they set.

We show that the rate at which the market depth (reciprocal of $\lambda$) increases with time is equal to the product of the informed trader's coefficient of risk aversion and the instantaneous volatility of liquidity trading. Equivalently, the depth at time $t$ is equal to some constant plus the product of the coefficient of risk aversion and the cumulative volatility. Since the latter quantity can be approximated by a series of lagged instantaneous volatilities, our model shows that depth is determined by past volatility of trade: the higher the volatility of trading is, the higher is the future depth. In view of our previous discussion, this prediction is natural. The higher the volatility of liquidity trading, the greater is the informed trader's intensity of trade, the faster information is incorporated into prices, and the faster $\lambda$ decreases (and depth increases) with time.

We also consider in our model elastic liquidity demand functions from a certain class. This class includes liquidity demand functions that are sensitive to $\lambda$, as in Admati and Pfleiderer (1988), and to the level of risk of the asset, i.e., the conditional variance of the asset, as in Massoud and Bernhardt (1999). Unlike these papers, however, the liquidity demand function is not endogenous.

Holden and Subrahmanyam (1994) study a model similar to ours in a discrete time setting with an inelastic liquidity demand function.[1] Our work is also an extension of Back (1992), who considers only the case of a risk neutral, informed trader in a continuous time setting. He shows that for general distributions of the liquidation value, $\lambda$ has to be a martingale. Back and Pedersen (1998) show that, under the assumption of normality, $\lambda$ is a martingale when the risk neutral, informed trader learns his information through time. Back, Cao and Willard (2000) study the risk neutral case with $N$ informed traders. In their model, $\lambda$ first decreases with time and later increases at an increasing rate until the information is publicly revealed. Massoud and Bernhardt (1999) provide a numerical solution to a three-period model with an endogenous liquidity demand function and a risk neutral informed trader. In their model, the motivation for liquidity trading is hedging liquidity shocks. Massoud and Bernhardt show that for different levels of risk aversion of the liquidity traders, $\lambda$ exhibits different time patterns. In particular, both increasing and decreasing patterns of $\lambda$ are consistent with their finite period

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[1] Holden and Subrahmanyam (1994) also model the case of $N$ traders with identical information. They suggest that as in the risk neutral case (see Holden and Subrahmanyam, 1992; Back et al., 2000) there is no linear equilibrium with long lived information. Therefore, we do not consider this case here.

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