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# The value of diffusing information ☆

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ABSTRACT

How does the speed by which information diffuses affect its value to a stock market investor? In a structural model solved in closed-form, this speed has two opposing effects on the empirically dominant term of the value of information. Faster-diffusing information means quicker and less noisy profits, but, also increases competing informed trading, impounding more information into prices and eroding profits. Structural empirical analysis of stock market reaction to drug approvals using media coverage as a proxy for the transmission rate of information finds that the value of information is hump-shaped in its future transmission rate. Moreover, the estimated amount of noise trading is small.



## 1. Introduction

How does the speed by which information diffuses affect its value to a stock market investor? Consider two drugs: Viagra treats erectile dysfunction while Allegra fights nasal allergies. Both drugs, if approved by the US Food and Drug Administration (FDA), would generate similar revenues to their publicly traded developers. When Viagra is approved, news of the approval diffuses fast because it makes for good conversation, while news of Allegra's approval travels slower. As an investor, would you pay more today to know that Viagra or Allegra will be approved tomorrow?

Theoretically, I show that faster-diffusing information can be more or less valuable. Intuitively, faster-diffusing information translates into a quicker realization of profits that are subject to less noise. However, competing informed agents trade more aggressively on faster-diffusing information, impounding more information into prices, thus decreasing the returns to informational trading. Empirically, the value of drug approval information turns out to be hump-shaped in its diffusion speed. Therefore, the most valuable information diffuses at a moderate speed.

I construct an asset pricing model in which the transmission rate of information determines equilibrium asset prices and volume. The model is a four-period noisy rational expectations model, à la Grossman and Stiglitz (1980), with asymmetric information about a risky asset that pays off in the post-announcement period. Information diffuses through

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a large population of risk-averse agents. The transmission rate controls the probability that uninformed agents in the pre-announcement period become informed for free in the announcement period. Pre-announcement, agents make their endogenous information choice, taking into account its future diffusion through both direct communication and indirect learning from prices.[1]

The main theoretical result provides a closed-form expression for the value of information given the transmission rate that has eluded previous studies of similar settings (Hirshleifer, Subrahmanyam, and Titman, 1994; Holden and Subrahmanyam, 2002). It is the sum of three terms. The first, and empirically dominant, term is positive and increasing in the intertemporal decline in uninformed agents' uncertainty. The transmission rate has two contrasting effects on this term. The first and more intuitive effect is that informational gains realized earlier are better than those realized only in the future that are subject to additional shocks. However, a second effect of this potential gain is that informed agents trade more aggressively, which makes pre-announcement prices more informative. The resulting reduction in pre-announcement uncertainty reduces the intertemporal decline in uncertainty and lowers the equilibrium value of information. This second effect happens holding the early informed fraction fixed. Unlike in Grossman and Stiglitz where strategic substitutability in information choice results from endogenous price informativeness, here price informativeness affects the value of information through the aggressiveness of informed agents.

The second term of the value of information is positive as well and has to do with the intertemporal decline in uncertainty of the informed relative to this decline by the uninformed. The third term is negative and represents the extent of information spillover to uninformed agents who do not pay for the signal. In contemporaneous work, Han and Yang (2013) study information acquisition and market efficiency in a one-period model with information spillovers over networks. In their model, only this third term survives, which explains why they find that the value of information is monotonically decreasing in its speed. The relative contribution of each of these terms to the total value depends on the parameters of the model, mainly the prior variances of the noisy supply and of the terminal payoff, and remains an empirical question, which I turn to next.

I estimate the parameters of the model and the magnitudes of the three terms of the value of information in a panel of FDA drug approvals, using media coverage as a proxy for the approval-specific transmission rate of information. Structural estimation reveals that the gradual information diffusion model quantitatively matches well many empirical moments of stock returns and volume around drug approvals. An open question about noisy rational expectations models is how much noise is keeping equilibrium prices from revealing the signal to the uninformed. A requirement of too much noise would question the validity of this theoretical assumption. Encouragingly, I estimate that non-informational supply shocks (noise) have a standard deviation of 1% of the total supply of the stock. Thus, the model requires only a small amount of non-informational trading to prevent prices from fully revealing the news.

Perhaps surprisingly, my main empirical finding is that the value of information is hump-shaped in the transmission rate of information of the fitted model and stems entirely from the first term, i.e. from its effect on the intertemporal decline in uninformed agents' uncertainty. This result means that, all else equal, the most valuable information to have early diffuses at a moderate rate later on. Furthermore, I find that the endogenous information choice feature of the model is crucial to match the magnitude of the negative covariation between the transmission rate and post-approval returns. In information market equilibrium, uninteresting news that propagates slowly is not pursued by anyone before the official announcement, because the fixed cost of information is prohibitively high. Faster-diffusing information is purchased at a higher rate, while the fastest diffusing news is somewhat less valuable. This unique feature of the model accentuates the covariation between transmission rates and the demand for the risky asset by influencing the extensive margin of information acquisition by the population as a whole.

My model builds on foundations laid by previous asset pricing theories with sequential information arrival. Hirshleifer, Subrahmanyam, and Titman (1994) randomly assign the informed population into early and late informed groups. In a similar setting, Holden and Subrahmanyam (2002) allow agents to purchase information in any of two periods of their model and investigate the serial correlation of stock returns and trade volume. I improve on their numerical work by characterizing the value of information in an intuitive closed-form expression. I further consider the problem of uninformed investors who randomly become informed in the future. Hong and Stein (1999) provides a behavioral model with information diffusion across a population of differentially and symmetrically informed newswatchers. The rational part of their model is closely related to my model. I extend their work with optimal learning from prices, information acquisition, and information asymmetry in the sense that different agents have different precision of information.

Information acquisition is also central in Veldkamp (2006), which studies media frenzies in emerging markets and uses the aggregate number of articles that reference an emerging market as a proxy for the cost of information in different environments. By contrast, the focus in my paper is on specific anticipated news and the market

[1] Money managers spread and exploit information over their social networks. Shiller and Pound (1989) provides survey evidence that direct interpersonal communication is important in investment decisions and that investor interest in specific stocks spreads like an epidemic. Hong, Kubik, and Stein (2005) provide further evidence that mutual fund managers spread information directly, through word-of-mouth communication. Furthermore, Cohen, Frazzini, and Malloy (2008) find that portfolio managers gain an informational advantage through education networks, and that their returns from this channel are concentrated around corporate news announcements. Consistent with the Stein (2008) model of truthful exchanges of information between competitors, Gray (2010) finds that skilled investors share their profitable ideas with their competition.