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Quality, price, and time-on-market

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HIGHLIGHTS

- A simple model of quality, price, and time-on-market for use by applied researchers.
- Sale prices fall with time-on-market (consistent with housing and labor markets).
- Comparative statics are obtained for search and learning parameters.

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ABSTRACT

Time-on-market is often interpreted as a negative signal of an asset's quality. The lengthier the time-on-market, the greater the probability that past buyers arrived, observed some undesirable quality, and chose not to buy. In this paper, I propose a simple model of quality, price, and time-on-market. The model yields closed-form expressions for beliefs, prices, and rates of sale. To demonstrate the accessibility of the model, I work out simple comparative statics for time-on-market and sale price and extend the model by giving the seller a valuable outside option.

1. Introduction

In labor markets, lengthy spells of unemployment result in lower wages (Kroft et al., 2013; Arulampalam, 2001), while in housing markets, lengthy marketing periods result in lower sale prices (Tucker et al., 2013; Dubé and Legros, 2016). The longer the asset – whether it be a worker's labor or a homeowner's house – remains on the market, the greater the probability that past buyers arrived, observed some undesirable quality, and chose not to buy. Buyers become pessimistic about the asset's quality and demand a lower price.

In this paper, I propose a simple, continuous-time model of asset quality, price, and time-on-market. A seller puts an indivisible asset on the market for sale, the quality of which is unknown to both the seller and to buyers. Buyers randomly arrive to inspect the asset, receive a noisy signal of quality, and choose whether or not to buy at the prevailing price. The model generates a negative relationship between time-on-market and sale price. More importantly, it yields simple expressions amenable to comparative statics and estimation.

This paper contributes to the literature on search and learning by introducing a simple modeling environment for use by applied researchers. The model depends on three intuitive parameters: the arrival rate of buyers, the informativeness of buyers' signals, and the value premium enjoyed by the owner of a high quality asset relative to the owner of a low quality asset.[1] To demonstrate the accessibility of the model, I work out simple comparative statics for time-on-market and sale price and extend the model by giving the seller a valuable outside option.

I obtain simple expressions by focusing on markets in which the asset trades at expected value. I note that when an asset trades at expected value – given its publicly observed time-on-market, but *not* given the buyer's privately observed signal of quality – the probability of sale depends only on the asset's quality. Put differently, a high-quality asset sells with some constant probability, while a low-quality asset sells with some other constant probability. Moreover, if buyers arrive at a constant rate, then the asset sells at a constant rate.[2]

In the model, the seller does not know the quality of her asset. I claim that this is the appropriate assumption for labor and housing markets. An asset's idiosyncrasies should not be confused with its quality. While the seller surely observes her asset's idiosyncrasies,

[1] Martel (2017) estimates these parameters in the market for single-family homes.

[2] I make the assumption of constant arrival to hew to Kaya and Kim (2017).

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she may not know how those idiosyncrasies compare to those of other assets for sale. A homeowner, for example, may know that her house has poor natural lighting and conclude that it is of low quality, unaware that the other house for sale in her neighborhood has even poorer natural lighting. Likewise, a job candidate may feel that he has strong programming skills and conclude that he is a high ability worker, unaware that the next candidate to be interviewed has even stronger programming skills.

Nevertheless, the model shares some important qualitative features with models of dynamic adverse selection in which the seller *does* know the quality of her asset. These models often feature an initial period of pooling or mixing by the seller of the low quality asset (Taylor, 1999; Daley and Green, 2012; Kaya and Kim, 2017). During this period, buyers form their beliefs about the asset's quality from exogenous sources of information and from the asset's time-on-market. The buyers modeled in this paper do precisely the same, not because of pooling or mixing, but because the seller simply does not know the quality of her asset.

The papers closest to mine are those of Taylor (1999) and Kaya and Kim (2017). Taylor (1999) develops a model in which the seller of a home conducts two sequential auctions. Short-lived buyers arrive at each auction and bid for the asset. The winning bidder receives a noisy signal of the asset's quality and may choose to walk away if the signal is unfavorable. He shows that second period bidders interpret the failure to sell in the first period as a negative signal of quality.

Kaya and Kim (2017) develop a continuous-time model in which a long-lived seller puts her asset on the market for sale, while short-lived buyers randomly arrive according to a Poisson process, receive noisy signals of quality, and make the seller private offers. They find that when initial beliefs are low (high), buyers' beliefs about the asset's quality increase (decrease) over time.

The model developed in this paper substantially differs from those of Taylor (1999) and Kaya and Kim (2017) in its treatment of prices. I leave unmodeled the auction or bargaining process between the seller and buyers and instead focus on markets in which the asset trades at expected value. I show that in such markets, the rate at which the asset sells depends only on its quality. Its price varies with time-on-market, but its probability of sale does not. Consequently, time-on-market is exponentially distributed. The PDF over time-on-market and sale price can be written explicitly in terms of elementary functions. In Taylor (1999), the seller chooses a reservation price, while in Kaya and Kim (2017), buyers choose offers to make to the seller. These choices cause both price *and* the probability of sale to vary with time-on-market. Time-on-market is no longer exponentially distributed and so the PDF over time-on-market and sale price must be defined implicitly.

Before proceeding to the model, I note that a substantial theoretical literature predicts a *positive* relationship between time-on-market and sale prices (Janssen and Roy, 2002; Daley and Green, 2012; Fuchs and Skrzypacz, 2013; Guerrieri and Shimer, 2014; Daley and Green, 2016; Fuchs et al., 2016; Daley and Green, 2017). In these models, the seller of a high quality asset – for whom holding costs are low – can signal its quality by delaying sale. Daley and Green (2012) study an environment in which information ("news") about asset quality is gradually revealed to the market by an exogenous process. In equilibrium, sellers of high-quality assets can obtain favorable prices by waiting for positive news. These models offer a novel explanation for the positive relationship between time-on-market and sale prices observed in certain markets. Adelino et al. (2016), for example, document a positive correlation between time-on-market and sale prices for mortgage backed securities. In other markets, information is obtained by interested buyers, and not by disinterested accountants, auditors, or journalists. "Good" news never becomes public, since its receiver buys the asset and ends trade. This paper compliments current work by considering these other markets.

The language herein may evoke the market for residential real estate. This is unfortunate, as the model just as well applies to the market for labor. The reader may substitute "ability" for "quality", "unemployment spell" for "time-on-market", "wage" for "price", "interview" for "inspection", "employer" for "buyer", and so on.

2. The model

Time is continuous and indexed by t. There is one long-lived seller and a countably infinite number of short-lived buyers. The seller owns an asset of quality $\theta \in \{H, L\}$. She does not know the quality of her asset. Let v_θ denote the value to a buyer of an asset of quality θ, where $v_H > v_L > 0$. Define the *value premium* to be $\zeta \equiv v_H/v_L$. A fraction $\pi_0 \in (0, 1)$ of assets are of quality H. Let v denote the random variable that takes the value v_H with probability π_0 and v_L with probability $1 - \pi_0$. Put $\bar{v} \equiv \frac{1}{2}(v_H + v_L)$. At time $t = 0$, the seller puts her asset on the market for sale. In the base model, the seller's decision to list is exogenous (an assumption relaxed in Section 2.2).

Buyers arrive for an inspection of the asset according to a Poisson process with a constant rate of $\lambda > 0$. Upon arrival, a buyer receives a private, IID signal $x|\theta$ with support $\mathbb{R}$. Let F_θ denote its CDF and f_θ its PDF. Define the likelihood ratio to be $\ell \equiv f_H/f_L$ and assume that $x|H$ and $x|L$ are such that ℓ is strictly increasing. Larger signals are more likely to have come from an H quality asset than from an L quality asset. For each $t \geq 0$, let $\pi(t) \in [0, 1]$ denote a buyer's belief that the asset is H quality, having arrived at time $t \geq 0$, and prior to having received her signal of quality.

The main assumption of the paper follows:

Assumption 2.1. Assets trade at expected value: $p(\pi) \equiv \pi v_H + (1 - \pi)v_L$.

p depends implicitly on t through π. As beliefs fall, the sale price falls. Recall that buyers are short-lived. Having arrived at time $t \geq 0$ and having received a signal of asset quality x, a buyer buys if and only if $\mathrm{E}_t[v|x] \geq p(\pi(t))$. Under Assumption 2.1, a buyer buys if and only if her expectation about the asset's quality *after* the inspection exceeds her expectation about the asset's quality *before* the inspection: $\mathrm{E}_t[v|x] \geq \mathrm{E}_t[v]$.

I now discuss how buyers' beliefs about the asset's quality must evolve. Let $t \geq 0$. Having received a signal of quality $x \in \mathbb{R}$, the buyer's expected value from owning the asset is

$$\mathrm{E}_t[v|x] = \frac{\pi(t)f_H(x)}{\pi(t)f_H(x) + (1-\pi(t))f_L(x)} \cdot v_H + \frac{(1-\pi(t))f_L(x)}{\pi(t)f_H(x) + (1-\pi(t))f_L(x)} \cdot v_L. \tag{1}$$

Lemma 2.1. *$\mathrm{E}_t[v|x] > p(\pi(t))$ if and only if $x > \ell^{-1}(1)$.*

Proof. From Eq. (1), $\mathrm{E}_t[v|x] > p(\pi(t))$ if and only if

$$\frac{\pi(t)\ell(x)}{\pi(t)\ell(x) + (1-\pi(t))} \cdot v_H + \frac{(1-\pi(t))}{\pi(t)\ell(x) + (1-\pi(t))} \cdot v_L > \pi(t)v_H + (1-\pi(t))v_L \tag{2}$$

if and only if

$$x > \ell^{-1}\left(\frac{1-\pi(t)}{\pi(t)} \cdot \frac{p(\pi(t)) - v_L}{v_H - p(\pi(t))}\right) = \ell^{-1}(1) \tag{3}$$

as desired. ■