The Impact of Information on the Properties of Price under the Different Market Structure

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Abstract

This paper provides a theoretical derivation of the stochastic properties of price when firms have private noisy information about random market demand. The focus of the analysis is the affect of the degree of competition on the conditional distribution of the price and the resulting implication for empirical analysis. I show that when firms have exogenously determined information of a given precision, the variance of price is a decreasing function of the degree of competition. In addition, it has been shown that when the precision of information is determined endogenously by firms' optimizing behavior, the variance of price could be increasing or decreasing in the degree of competition depending on the cost of information and the convexity of production costs.

I. Introduction

There have been numerous empirical investigations of the relationship between price and competitiveness in a variety of markets, including air transportation, insurance, banking services, newspaper and radio advertising, groceries, gasoline and many
others. Empirical analyses of this relationship typically specify a reduced form equation of prices as a linear function of the degree of competitiveness as measured by the Herfindahl-Hirschman or other concentration index, and variables that determine cost and demand. Schmalensee (1989) summarizes the results of these studies as a stylized fact: "In cross-section comparisons involving markets in the same industry, seller concentration is positively related to price."

As well known, these studies also show that price responses to a change in cost or demand vary with the degree of competitiveness, although the relative sizes of price responses are indeterminate. Carlton (1989) illustrates this point by showing that when total cost is linear, a change in marginal cost will cause a greater change in competitive prices than in monopoly prices if demand is linear, but the converse is true if demand is log-linear. Furthermore, he shows the various results of recent studies which explain the relationship between price variation and market structure. However, most of studies do not consider in detail how the firms react against private imperfect information to bring about the different relationships between price variation and competitiveness.

This paper investigates the theoretical relationship between competitiveness and the stochastic properties of price when demand and/or cost are stochastic and firms have imperfect private information about their realized values. Firms determine their output based on available information, and the equilibrium price is determined where the market clears. The equilibrium price thus becomes intrinsically stochastic: its properties depending on the stochastic nature of demand/cost, and, more importantly, on how firms respond to the uncertainty and their information. The major point of this paper is that the effect of information on firms' output decision varies with the degree of competition. This is analogous
to the differential effect of a change in cost on the mean price, but the information effect, which will be shown later, is on the variance of the equilibrium price. Differences in competitiveness thus lead to differences in the variances as well as in the means of equilibrium prices.

Differences in variances of the price raise the issue of the relationship between competitiveness and the volatility of price. Previous studies on this issue are concerned about gross volatility, and focus on the price variation due to changes in variables that determine cost or demand. Carlton (1989) for example, refers to the variation of mean price when he explains that "the simple theories do not allow any differential predictions of price flexibility...that depend solely on the degree of competitiveness of the market." A recent study of price volatility in metals markets by Slade (1991) also involves the gross volatility, and concentrates on the effects of the stability of cost and demand variables in addition to market concentration. These studies are essentially analyses of the mean price function. The current paper adds a new dimension to the analysis of price volatility by presenting a systematic relationship between the variance of the equilibrium price and the degree of competitiveness.

The rest of the paper is organized as follows. Section 2 presents the two-stage game model where firms face a stochastic demand function and have a non-stochastic convex cost function. Each firm can acquire private noisy information about the stochastic demand. Equilibrium strategies derived in Hwang (1995) are summarized in Section 3. The mean and variance of equilibrium price and price-cost margin are examined in Section 4 for two cases. The first case is when competitive, oligopoly, and monopoly firms have identical information and the second case is when information precision is endogenously determined. Section 5 concludes the paper with a summary of the findings.
II. Specification of the Model

Each firm has an identical convex cost function \( C(q_i) \), and faces a stochastic inverse demand function \( P = P(Q; \bar{a}) \), where \( Q = \Sigma q_i \) and \( \bar{a} \) is a stochastic shift parameter. The distribution of \( \bar{a} \) is common knowledge to all firms, and it has a finite mean \( \mu \) and precision \( \nu^2 \). The mean demand may be considered as a nonstochastic function of demand shifting variables such as income, prices of substitutes, and etc. We assume the same demand and cost functions in all markets with different degrees of competition to isolate the effects of the differences in competition. The assumption of stochastic demand and nonstochastic cost functions is not critical. The analysis in this paper will be the same when the cost function or both functions are stochastic, with a proper reinterpretation of the results.

Firms can acquire private information on the true (realized) value of \( \bar{a} \) in the form of a noisy signal \( Z_i = \bar{a} + \varepsilon_i \), where the random noise \( \varepsilon_i \) has zero mean and precision \( t_i \). Each firm can increase the precision \( t_i \) of information at a constant marginal cost \( \lambda \). It is assumed that the noise in the information signal is mutually uncorrelated, and also uncorrelated with the shift parameter \( \bar{a} \): \( \text{cov}(\bar{a}, \varepsilon_i) = \text{cov}(\varepsilon_i, \varepsilon_j) = 0 \) for \( i \neq j \). And the conditional mean of \( \bar{a} \) given the signal, \( E(\bar{a} | Z_i) \), is assumed to be affine in \( Z_i \). For a discussion of the distributions consistent with an affine structure, see Vives (1988). Under these assumptions we have

\[
E(\bar{a} | Z_i) = (Z_j | Z_i) = \mu + \delta_i (Z_i - \mu) 
\]

(1)

\[
\text{cov}(\bar{a}, Z_i) = \text{cov}(Z_i, Z_i) = \frac{1}{\nu}, \quad i \neq j
\]

(2)

where \( \delta_i = t_i/(t_i + \nu) \) is a monotonically increasing function of \( t_i \) and has a support \([0,1]\). We will use \( t_i \) and \( \delta_i \) interchangeably as the precision of information in the following analysis.
Firms' decisions are made in two stages. In the first-stage of the game, each firm determines the amount of information to acquire by selecting the precision level $t_i$. Once each firm selects $t_i$, they become public information. However, the realized value of the signal $Z_i$, which each firm receives in the second-stage, remains private information. In the second-stage, each firm determines its output level conditional on its own signal value $Z_i$ and other public information.

Competitive equilibrium is often characterized in the literature as the limit of a sequence of Cournot oligopoly equilibria as the number of firms goes to infinity (see Palfrey (1985), Li, McKelvey and Page (1987), and Vives (1988)). At the limit, Cournot oligopoly firms eventually become price takers. This definition is not useful for our purpose of comparing competitive and oligopoly equilibria with a finite number of firms. Hwang (1995) specifies the competitive equilibrium as a member of the parametric "conjectural variations" oligopoly model with a finite number of firms. Let $\kappa = \partial E(q_i|Z_i)/q_i$ denote the expected conjectural variation, where $\kappa = -1$ for competitive firms, 0 for Cournot oligopoly firms, and 1 for monopoly firms.

The conjectural variations oligopoly model is subject to some well merited criticism, but it provides us with a convenient way "to capture the idea of varying degrees of competition". Moreover, this framework is consistent with the "new empirical industrial organization," which attempts to estimate the "strategic interaction parameter" from the observable data on price, quantity, and other variables that determine the cost and demand functions. The strategic interaction parameter measures the degree of competition, and is equivalent to the conjectural variation (see Bresnahan (1989)). Schmalensee (1989) also uses the conjectural variation formalism to summarise the firm's conduct in his illustration of the argument that efficiency differences provide an alternative
explanation for the positive relation between concentration and profitability.

III. Equilibrium Strategies

In the second stage of the game, each firm determines its output level to maximize expected profit conditional on its private information $Z_i$:

$$E(\pi_i \mid Z_i) = q_i E(P \mid Z_i) - C(q_i) - \lambda_i$$  \hspace{1cm} (3)

subject to the behavioral assumption about the conjectural variation. Given the second stage equilibrium strategies, the first stage choice of information precision is found by maximizing the ex ante (unconditional) expected profits with respect to $t_i$. To find closed form solutions for the Bayesian-Nash equilibria we follow the standard assumptions of linear demand and linear marginal cost functions in the literature

$$P(\theta) = \bar{a} - b\theta, \quad \theta = \sum q_i, \quad b > 0$$

$$C(q_i) = cq_i + \frac{e}{2}q_i^2, \quad \mu > c > 0, \quad e \geq 0$$  \hspace{1cm} (4)

We also assume for mathematical convenience that there are only two firms. Under these assumptions, Hwang (1995) shows the following first and second stage results.

Proposition 1. Let $\tau = e/b$ be the ratio of the slope of the marginal cost function to the slope of the demand function, and let $\phi = \tau + \kappa + 2$.

(a) The unique linear Bayesian equilibrium strategy in the second stage is given by

$$q_i = \alpha + \beta_i(Z_i - \mu), \quad \alpha = \frac{\mu - c}{b(\phi + 1)}, \quad \beta_i = \frac{\delta_i(\phi - \delta_i)}{b(\phi^2 - \delta_i\delta_i)}$$  \hspace{1cm} (5)

At the symmetric information equilibrium $\delta = \delta_1 = \delta_i$, we have $\beta = \beta_i =$
\[ \beta_j = \delta / [b(\phi + \delta)] \]

(b) At the symmetric interior equilibrium precision of information, (i) competitive firms acquire less information than oligopoly and monopoly firms, and (ii) oligopoly firms acquire more or less information than monopoly firms, depending on the information cost and the convexity of the cost function.

**Proof.** See Hwang (1995) for the proof.

Equilibrium quantity of output in (5) has two components. The first component, \( \alpha \), represents the ex ante expected output level, which is increasing in the degree of competition. That is, when there is no additional information, expected output level is greatest for competitive firms followed by that for oligopoly and then the monopoly. The second component, \( \beta_i (Z_i - \mu) \), represents the degree to which firms adjust their output level based on their information signal, \( Z_i \). If the signal indicates a higher demand than expected a priori, firms revise their estimates of the demand upward and increase their output levels.

The output calibration to the perceived change in demand under uncertainty is smaller than that under certainty because of the noise in the information signal. More precise information increases the frequency of output adjustment in the right direction and makes firms adjust their output levels more aggressively to the information signal. When all firms have information of the same precision, competitive firms will undertake the largest output adjustment for a given signal and monopoly firms the smallest. This difference in firms' responses to a change in demand is consistent with the well-known results under certainty.

Given the second stage equilibrium strategies, the symmetric equilibrium precision of information that maximizes ex ante (unconditional) expected profits in the first stage is determined by
\[ MB(\delta) = \frac{b(k + \phi)}{2} \frac{(1 - \delta)^2(\phi^2 + \delta^2)}{b^2 \delta^2 (\phi + \delta)^3 (\phi - \delta)} = \lambda \] (6)

where \( MB(\delta) \) is the monotonically decreasing marginal benefit of information precision. The first term in \( MB(\delta) \) represents the curvature of the profit function, and the second term the marginal effect of information precision on the firm's output calibration toward the full-information optimum output level. It is well known that the curvature of the profit function is smallest for the competitive firms and largest for the monopoly firms. The marginal calibration effect of information precision is a decreasing function of the firm type parameter \( \kappa \), and hence is the largest for the competitive firms. Consideration of the net effects of these two offsetting factors leads to the results in Proposition 1.b).

Note that regardless of the degree of competition, the marginal benefit of information approaches zero as firms' information becomes perfect (\( \delta = 1 \)). This implies that if information is free, \( \lambda = 0 \), then all types of firms will have perfect information, the case of certainty. On the other hand, firms will not acquire any information (\( \delta = 0 \)) if information cost is sufficiently high. Differences in the precision of information at an interior equilibrium and differences in the firms' output adjustment to a given signal play a key role in the relative volatility of equilibrium prices and price-cost margins.

**IV. Mean and Volatility of Equilibrium Prices and Price-Cost Margins**

In this section we consider the effects of the degree of competition on the expected level and the volatility of equilibrium
prices and price-cost margins, where volatility is measured by the variances. From Proposition 1 we have \( q = a + \beta(Z - \mu) \) and \( Q = 2\alpha + 2\beta(\bar{a} - \mu) + \beta(\varepsilon_1 + \varepsilon_2) \) at the symmetric information equilibrium. Substituting these into the inverse demand and the marginal cost functions, we can write the equilibrium price and the price-cost margin as

\[
P = (\mu - 2ab) + (1 - 2\beta b)(\bar{a} - \mu) - \beta b(\varepsilon_i + \varepsilon_j)
\]

\[
P - MC_i = [\mu - c - (\tau + 2)ab] + [1 - (\tau + 2)\beta b](\bar{a} - \mu) - (\tau + 1)\beta b \varepsilon_i - \beta b \varepsilon_j,
\]  \hspace{1cm} (7)

and their expected values are

\[
EP = E(P) = \mu - 2ab = \frac{(\tau + \kappa + 1)\mu + 2c}{\tau + \kappa + 3}
\]

\[
EPC = E(P - MC_i) = (\mu - c) - (\tau + 2)ab = \frac{(\mu - c)(\kappa + 1)}{\tau + \kappa + 3}
\]  \hspace{1cm} (8)

Before we discuss the relationship between price volatility and competitiveness, it is worthwhile to investigate equations above. The mean price and the mean price-cost margin are an increasing function of mean demand, and a decreasing function of the degree of competition. The mean price is also an increasing function of the marginal cost parameters \( c \) and \( e \) though the mean price-cost margin is decreasing in these parameters. The expected price-cost margin for the competitive firms is zero, while that for the oligopoly and monopoly firms is positive. These are well known results under certainty, and are the basis for empirical specifications and hypotheses tests of linear regression equations of prices or price-cost margins against demand and cost shift variables and a concentration index as a proxy for the degree of competition.

Previous studies of the relationship between competitiveness (industry concentration) and price volatility (variation of price) or price rigidity (frequency of price change) are concerned about changes in price in relation to the variation of cost or demand variables. As noted earlier, this is equivalent to the analysis of
the mean price function. We examine below the volatility of price and price-cost margin as measured by their variances. The coefficient of variation is another useful measure of volatility when prices under consideration have different means, which is useful to find empirical implications on the properties of the error terms in price regression models for the future analysis. The analysis of the coefficient of variation is summarized at the end of this section.

At the symmetric information equilibrium, volatility of the equilibrium prices and the price-cost margins as measured by their variances can be easily computed from (7):

\[
VP \equiv \text{var}(P) = (1 - 2\beta \delta)^2 \text{var}(\bar{a}) + 2(\beta \delta)^2 \text{var}(\epsilon_i) = \frac{1}{h} \cdot \frac{2\delta(2\phi + \delta - 1)}{h(\phi + \delta)^3} \\
VPC \equiv \text{var}(P - MC) = [1 - (\tau + 2\beta \delta)] \text{var}(\bar{a})[((\tau + 1)^2 + 1)(\beta \delta)^2 \text{var}(\epsilon_i)]
\]

\[
= \frac{1}{h} \cdot \frac{2\delta(2\phi + \delta - 1 + \tau(\kappa + 1))}{h(\tau + \delta)^3}
\]

where we use the fact that \text{var}(\epsilon_i) = \text{var}(\epsilon_j) = (1 - \delta) / h \delta at the symmetric information equilibrium, and the assumption that information noises are mutually uncorrelated and also uncorrelated with the random shift of demand \bar{a}.

When firms have no private information on demand (\delta = 0), they set their output at the expected level \bar{a} and have no reason to adjust their ex ante decisions (\beta = 0). Consequently, both VP and VPC are equal to the underlying volatility \text{var}(\bar{a}) of the stochastic demand, and there is no difference across the types of firms. Information on demand allows firms to adjust their output levels to the direction of the change in demand, and thus can reduce the volatility of price. The adjustment of output, however, is not always in the right direction because of the noise in the imperfect information. Changes in output that originate from the change in information noise can exacerbate the price volatility. The first term of VP in (9) represents the auspicious effects of information
that reflects changes in demand, and the second term the destabilizing effect of information noise. A similar interpretation applies to the volatility of the price-cost margin.

The destabilizing effect of information noise decreases as the information precision improves. Hence, \( VP \) and \( VPC \) are monotonically decreasing in information precision \( \delta \). Note that, if the marginal cost is constant (\( \tau = 0 \)), then the price and the price-cost margin have the same volatility. When \( \tau > 0 \), the information noise increases \( VPC \) through its effects on marginal cost, but a strong positive correlation between price and marginal cost more than offsets this effect. The net effect is that the price-cost margin is less volatile than the price.

We showed earlier that, when firms have information of identical precision, the degree of output adjustment \( \beta \) varies among different types of firms. Competitive firms are most sensitive and monopoly firms are least sensitive to information. Therefore, given identical information precision \( \delta \), both the stabilizing and destabilizing effects of the noisy information are greater for the competitive firms than for other types of firms. The net effects are compared across the types of firms in the following proposition.

**Proposition 2.** The volatility of the equilibrium price and the price-cost margin is the lowest in the competitive market and the highest in the monopoly market when firms have information of identical precision \( \delta > 0 \), and it is the same across the markets when firms have no private information (\( \delta = 0 \)).

**Proof.** Differentiating \( VP \) and \( VPC \) in (9) with respect to \( \kappa \), it is easy to show that \( VP \) and \( VPC \) are monotonically increasing \( \kappa \) for all \( \kappa \geq -1 \). If \( \delta = 0 \), then \( VP = VPC = 1/h \) and they do not depend on \( \kappa \). Q.E.D.
The price volatility is the same across the markets when firms have no information. But if firms have information, the competitive price can be more volatile than the prices in other types of markets. This is illustrated in Figure 1, where VPC, VPd and VPM represent the price volatility in the competitive, oligopoly and monopoly markets, respectively. Figure 1 shows that, for any given information precision $\delta_m$ of monopoly firms, there exists a unique information precision $\delta_{cm}$ and $\delta_{dm}$, respectively, for competitive and oligopoly firms, such that $VPC(\delta_{cm})=VPd(\delta_{dm})=VPM(\delta_m)$. Similarly, there exists a unique $\delta_{cd}$ for competitive firms for any given information precision $\delta_d$ of oligopoly firms, such that the two markets have the same price volatility, i.e., $VPC(\delta_{cd})=VPd(\delta_d)$. The competitive market has a more volatile price than the oligopoly or monopoly market if competitive firms have information precision lower than $\delta_{cm}$ or $\delta_{cd}$, and the oligopoly market will have a more volatile price than the monopoly market if $\delta_d$ is lower than $\delta_{dm}$.

Differences in information precision among the three types of firms can arise for a variety of reasons. In this paper, we are concerned about the differences in firms' incentives to acquire costly information that lead to the differential information precision. Let $\delta^e_c$, $\delta^e_d$ and $\delta^e_m$ denote the equilibrium precision of information of competitive, oligopoly and monopoly firms, respectively, and let $\delta_{cm}$, $\delta_{cd}$ and $\delta_{dm}$ be as defined above at the monopoly and oligopoly equilibriuc precision. Proposition 1 shows that competitive firms acquire less precise information than other types of firms when they face the same information cost, while oligopoly firms may acquire more or less information than monopoly firms. We investigate below the relative price volatility at endogenous
information equilibria by examining the relationships of $\delta_c^e$ against $\delta_{cd}$ and $\delta_{cm}$, and of $\delta_d^e$ against $\delta_{dm}$.

Consider first the case of a constant marginal cost ($\tau=0$). The competitive firms' marginal benefit of information $MBc(\delta_c)=0$ for all $\delta_c$ in this case and hence, competitive firms do not acquire costly information ($\delta_c^e=0$). Since $\delta_c^e$ is lower than $\delta_{cd}$ and $\delta_{cm}$ for any positive oligopoly or monopoly equilibrium, the competitive price is more volatile than the prices in other markets. This contrasts with the case of exogenous identical precision of information. For the relationship between the oligopoly and monopoly, Hwang (1995) shows that $\delta_d^e > \delta_m^e$ when $\tau=0$, which implies $\delta_d^e > \delta_{dm}$ because $\delta_{dm}$ is less than $\delta_m^e$. Therefore, the oligopoly market has a less volatile price than the monopoly market, the same result as the case of exogenous identical information.

Even in the case of an increasing marginal cost ($\tau>0$) competitive firms may not acquire information while other types of firms do. To see this, let $\lambda_c$, $\lambda_d$ and $\lambda_m$ be the maximum information costs, below which each type of firm acquires information. These maximum information costs are functions of the volatility of demand ($1/h$) and the slope of the marginal cost. It is easy to verify from (6) that $\lambda_c < \lambda_m < \lambda_d$. This gives the following relationships for any $\tau>0$.

**Proposition 4.** (a) If information cost is sufficiently high ($\lambda \geq \lambda_d$), then firms do not acquire information and $VP_c=VP_d=VP_m=1/h$.

(b) If information cost is in the upper mid-range ($\lambda_m \leq \lambda < \lambda$
d), then competitive and monopoly firms do not acquire information, while oligopoly firms do. Hence, $V_P^c = V_P^m > V_P^d$. If information cost is in the lower mid-range ($\overline{\lambda}_c \leq \lambda < \overline{\lambda}_m$), then $V_P^c > V_P^m$ and $V_P^c > V_P^d$.

(c) If the information cost is below $\overline{\lambda}_c$, there exist information costs $\lambda_{cd}$ and $\lambda_{cm}$ for each $\tau > 0$, such that $V_P^c = V_P^d$ for $\lambda = \lambda_{cd}$, and $V_P^c = V_P^m$ for $\lambda = \lambda_{cm}$.

(d) $V_P^d$ is smaller than $V_P^m$ for all $\lambda < \overline{\lambda}_d$.

Proof. (a) and (b) It is straightforward and thus omitted.

(c) Let $\delta_m^\varepsilon$ be the monopoly firms' equilibrium information precision, i.e., $\lambda = MBm(\delta_m^\varepsilon)$, and consider $\lambda$ as a function $\delta_m^\varepsilon$. Since an increase in $\delta_m^\varepsilon$ is equivalent to a decrease in $\lambda$, competitive firms' equilibrium precision $\delta_c^\varepsilon$ is a monotonically increasing function of $\delta_m^\varepsilon$ as shown in Figure 2. The $\delta_c^\varepsilon$ curve reflects the facts that $\delta_c^\varepsilon < \delta_m^\varepsilon$ for a $\lambda > 0$ by Proposition 1, $\delta_c^\varepsilon = 0 < \delta_m^\varepsilon$ for $\overline{\lambda}_c \leq \lambda < \overline{\lambda}_m$, and $\delta_c^\varepsilon = 1$ when $\delta_m^\varepsilon = 1$ (i.e., $\lambda = 0$). The $\delta_{cm}$ curve at which $V_P^c(\delta_{cm}) = V_P^m(\delta_m^\varepsilon)$ is also monotonically increasing in $\delta_m^\varepsilon$, and $\delta_{cm} = 0$ for $\delta_m^\varepsilon = 0$, and $\delta_{cm} < 1$ for $\delta_m^\varepsilon = 1$. Therefore, the fixed point theorem assures the existence of a $\delta_m^*$ and corresponding information cost $\lambda_{cm} = MBm(\delta_m^*)$, such that $\delta_c^\varepsilon = \delta_{cm}$ and $V_P^c = V_P^m$. The existence of $\lambda_{cd}$ can be proven analogously by proving the existence of $\delta_d^*$ where the $\delta_c^\varepsilon$ and $\delta_{cd}$ curves as a function of $\delta_d^*$ intersect each other.
(d) The $\delta_{dm}$ curve at which $\text{VPd}(\delta_{dm}) = \text{VPm}(\delta^e_{m})$ has the properties similar to the $\delta_{cm}$ curve in Figure 2. On the other hand, the $\delta^e_{d}$ curve has a positive vertical intercept because $\delta^e_{m} = 0 < \delta^e_{d}$ for $\lambda_m \leq \lambda < \lambda_d$, and $\delta^e_{d} = 1$ when $\delta^e_{m} = 1$. If the $\delta^e_{d}$ curve lies above the 45° diagonal line for all $\delta^e_{m} < 1$, it implies that oligopoly firms acquire more information than monopoly firms, and $\text{VPd} < \text{VPm}$. Proposition 1 shows that $\delta^e_{d}$ can be smaller than $\delta^e_{m}$ for some values of $\tau$, which implies that the $\delta^e_{d}$ curve can cross the 45° line. Even in such a case, it can be shown that the difference between $\delta^e_{m}$ and $\delta^e_{d}$ is sufficiently small and $\delta^e_{d} > \delta_{dm}$, and hence $\text{VPd} < \text{VPm}$. Q.E.D.

When the information cost is sufficiently low, the competitive price is least volatile at the information equilibrium. This implies that, though competitive firms acquire less information than other types of firms, the difference in information precision is not large enough ($\delta^e_{c} > \delta_{cm}$ and $\delta^e_{c} > \delta_{cd}$). As the information cost rises, the competitive price becomes more volatile than the oligopoly price, and then becomes most volatile, as long as all firms acquire information. The set of information cost for which the competitive price is most volatile is small if the marginal cost curve is steep, but it is quite substantial when the marginal cost curve is relatively flat. Sizes of the price volatility can also be significantly different.

To summarize, when information precision is determined endogenously, different types of firms acquire different amount of information, which leads to different price volatilities in general. At the information equilibrium, the competitive market price can be more or less volatile than the oligopoly and monopoly prices, while
the oligopoly price is more stable than the monopoly price. An important empirical implication is that the price volatility cannot be the same in all three types of markets, except when the information cost is sufficiently high and no firms acquire information.

V. Conclusion

The relationship between the variance of price and the degree of competition has received considerable attention in the empirical literature, but very little notice from a theoretical perspective. One of exception is Evans, Froeb, and Werden (1993) who argue that the regression error terms can be correlated with the measure of the degree of competition. However, the source of this correlation is a measurement issue relating to the construction of concentration indices and has little to do with firms' optimizing behavior. Our theory suggests that as a result of firms' behavior and differential incentives to acquire information, the variance of price is a systematic function of competition, which causes a heteroskedasticity problem of error term.

The nature of the relationship between the variance of price and the degree of competition will depend on whether the precision of information is given exogenously or determined endogenously by firms' optimizing behavior. If information of identical precision is given exogenously, then the variance of price is strictly decreasing in the degree of competition the competitive equilibrium yielding the most stable price and monopoly the least. When information precision is determined endogenously, then monopoly and oligopoly firms acquire more information than competitive firms. If the difference in information precision is sufficiently large (the difference determined by the cost of information and the convexity
of the production cost function) then the monopoly and oligopoly equilibria may generate a more stable price than under competitive behavior.

This paper assumes that the cost of information is constant with respect to the degree of competition. Domberger (1979) finds a positive relationship between the speed of price adjustment and industry concentration in UK manufacturing data. He argues that this finding is consistent with the cost of information decreasing with increased concentration (the degree of competition). The heuristic theory of Eckard (1982) makes this same point. In the present context, this would reinforce the incentive of firms in less competitive markets to acquire more information. In so doing, this could exacerbate (reduce) the variance of price error terms if information cost is high (low) relative to the convexity of production cost.

VI. REFERENCES


Figure 1. Relative Volatility of Price
Identical Information Precision

Figure 2. Existence of Information cost for $V_{pc}=V_{Pm}$