Economics Bulletin

Volume 42, Issue 4

Chicago price theory meets imperfect competition: A common ownership approach

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Abstract

In this paper, we provide a formulation of how imperfect competition in the product market is incorporated into the industry model described in Chapter 11 of Chicago Price Theory (Jaffe, Minton, Mulligan, and Murphy 2019, CPT). A generalized version of the perturbed system of the industry is shown and used to analyze the effect of a wage increase in the long-run as well as in the short-run in relation to the intensity of competition.

We are grateful to Parimal Bag and a referee for their insightful comments. We also thank Hiroaki Sasaki and the participants at the Economic Dynamics Workshop at Kyoto University for a stimulating discussion. Adachi acknowledges a Grant-in-Aid for Scientific Research (C) (18K01567, 21K01440) from the Japan Society of the Promotion of Science. Any remaining errors are ours.
Citation: Takanori Adachi and Leer Bao, (2022) "Chicago price theory meets imperfect competition: A common ownership approach", *Economics Bulletin*, Volume 42, Issue 4, pages 1848-1857
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Submitted: August 23, 2022. **Published:** December 30, 2022.

1 Introduction

Market competition is one of the key concepts at the core of price theory. Following this tradition, *Chicago Price Theory* (Jaffe, Minton, Mulligan, and Murphy 2019, *CPT*)—a recently published textbook for graduate microeconomics based on the legendary course taught at the University of Chicago—emphasizes the importance of studying market equilibrium *at the aggregate level*. This methodological stance stands in sharp contrast to game theory, which "typically focuses on interactions among small numbers of agents" (*CPT*, p. 3). Currently, it is widely held that *imperfect competition*, one of the most prominent characteristics in modern economy, is fairly an advanced topic, and therefore should be taught only after game theory is introduced.

Perhaps, this common view is too narrow. To convince the reader of why, this paper proposes a *common ownership approach* to provide a synthesis of imperfect competition in the product market and price theory in its traditional style. Common ownership describes a situation in which a small number of institutional investors own large shares of big firms: it may weaken competition between firms in an industry, resulting in non-negligible markup.[1] We take this possibility of common ownership into account in our model below.

In this way, imperfect competition can be taught when the interaction of supply and demand at the aggregate level is introduced, as in *CPT*'s Chapter 11 ("The Industry Model"). Additionally, this methodology enables one to escape from the (mis)belief that imperfect competition is one of the market failures and hence should be treated only as a special case. Rather, this common ownership approach makes it clear that it *is* perfect competition that should be treated as a special case of imperfect competition.

The rest of the paper is organized as follows. The next section illustrates how the industry model of single product under the assumption of perfect competition is generalized to include imperfect competition. In particular, the generalized version of the perturbed system of the industry is presented. Then, in Section 3, we use this result to analyze the effect of a wage increase in the short-run as well as in the long-run. Specifically, we obtain the following testable prediction: when the industry faces an increase in the (perfectly competitive) price of labor or capital, a *weaker intensity of competition* in the product market, *ceteris paribus*, facilitates *more substitution* toward the use of the other input in the long-run, and in the short-run, *stronger reaction* of the other input's price. Lastly, Section 4 concludes.

2 The Industry Model

We start with the description of the Industry Model under perfect competition in Chapter 11 of *CPT*. Then, we argue how imperfect competition is incorporated into this Industry Model, and show how the perturbed system of the Industry Model is generalized.

[1] See, e.g., Schmalz (2018) for an introductory survey and references therein

2.1 Preliminaries

Let $D(P)$ be the industry's demand, where $P > 0$ is the industry-level price. Throughout this paper, we consider the optimal production of one "representative firm" à la Marshall (1890/1920), which is a conceptual entity consisting of symmetric firms.[2] Then, this industry/firm's marginal cost is denoted by $MC(Y)$, where $Y > 0$ is the aggregate output in the industry. We assume that both $D(P)$ and $MC(Y)$ satisfy the standard restrictions. There are no fixed costs for this production.

Given the wage rate $w > 0$ and the rental rate $r > 0$, and under the assumption of *Constant Returns to Scale* (CRS), the cost function, $C(w, r, Y)$ satisfies: $C(w, r, Y) = Y \cdot C(w, r, 1)$, and thus the marginal cost of production is *constant*: $MC(Y) = C(w, r, 1) \equiv c \geq 0$ for any $Y > 0$. In addition, let $L > 0$ and $K > 0$ be labor and capital inputs, respectively, for the production process that is summarized by the production function, $Y = F(L, K)$. We also assume that the regular properties hold for this production function so that the existence of the solution and its uniqueness are guaranteed.

Under this setting, *CPT* presents the Industry Model under perfect competition, which is described by the following system of "four ingredients" (p. 131):

$$\begin{cases} 1.\ \dfrac{P - MC}{P} = 0 \\ 2.\ Y = D(P) \\ 3.\ L = \dfrac{\partial C(w,r,Y)}{\partial w} \quad \text{and} \quad K = \dfrac{\partial C(w,r,Y)}{\partial r} \\ 4.\ Y = F(L, K), \end{cases}$$

in which the only modification from *CPT*'s original description appears in the first equation: here, it explicitly states that the *markup rate* is zero under perfect competition, whereas *CPT* simply writes this condition as $P = MC$. The second equation requires that the demand and the supply in the product market be equal in equilibrium, and the third implies that the firm is a price taker in the input market. Finally, the last equation describes the connection between output Y and inputs L and K.

Let Δ denote the *percentage* change (e.g., $\Delta P \equiv \frac{dP}{P} = d \ln P$).[3] Then, *CPT* provides the perturbed system of this perfectly competitive industry:

$$\begin{cases} \Delta P = s_L \Delta w + s_K \Delta r \\ -\Delta Y = (-\epsilon^D) \Delta P \\ \Delta L - \Delta K = \sigma \cdot (\Delta r - \Delta w) \\ \Delta Y = s_L \Delta L + s_K \Delta K, \end{cases} \qquad (*)$$

where $s_L \equiv \frac{wL}{PY}$ and $s_K \equiv \frac{rK}{PY}$ are the labor share and the capital share of aggregate income (excluding corporate profit), respectively, $\epsilon^D \equiv \frac{P}{Y} \frac{dD(P)}{dP} < 0$ is the price elasticity of the *industry's* demand, and $\sigma > 0$ is the *elasticity of substitution*, defined by $\Delta \frac{L}{K} = \sigma \cdot \Delta \frac{r}{w}$.

[2] A moderate degree of firm heterogeneity would be readily incorporated, although the main thrust would not change significantly, whereas the notation would become heavier (see, e.g., Adachi and Fabinger 2022).

[3] We follow *CPT* to use Δ to mean a percentage–rather than absolute–change.

2.2 Industry Model under Imperfect Competition

Now, we generalize this Industry Model to include imperfect competition in the following manner. First, suppose that there are $n \geq 2$ identical firms and that each firm j's objective function is the sum of its own profit, π_j, and the other rivals' profits: $\widehat{\pi}_j = \pi_j + \kappa \sum_{k \neq j} \pi_k$, where $\kappa \in [0, 1]$ denotes the *"cooperative attitude"* (Shubik 1980, p. 42) in the industry that is interpreted as the *"degree of common ownership"* (López and Vives 2019; Adachi 2020b, Sato and Matsumura 2020; Backus, Conlon, and Sinkinson 2021).

We next define the *conduct "parameter" under price competition*, where each firm j faces its own demand $q_j = q_j(\boldsymbol{p})$, where $\boldsymbol{p} = (p_1, p_2, ..., p_n)$, and chooses its price, p_j, by

$$\theta(P) = \frac{1}{(1-\kappa)\dfrac{\epsilon_{own}(P)}{\epsilon^D(P)} + \kappa},$$

where $P \equiv p_1 = p_2 = ... = p_n$ is the symmetric price, and $\epsilon_{own}(P) \equiv \frac{P}{q}\frac{\partial q_j}{\partial p_j}(P, P, ..., P) < 0$ denotes the equilibrium *own* price elasticity of the individual firm's demand (under symmetric pricing), where $q \equiv q_1 = q_2 = ... = q_n$ is the the associated per-firm quantity, and the equilibrium price elasticity of market demand *at the individual firm's level* is defined by $\epsilon^D(P) \equiv \frac{Pq'(P)}{q(P)} < 0$. Note here the conduct parameter is not totally exogenous as it is a function of P. However, it is also regarded as a parameter because it indicates how the intensity of competition is determined, depending on such exogenous factors as product differentiation and common ownership.

Now, the first-order condition for firm j is given by

$$\frac{\partial \widehat{\pi}_j}{\partial p_j} = q_j(\boldsymbol{p}) + (p_j - c)\frac{\partial q_j}{\partial p_j}(\boldsymbol{p}) + \kappa \sum_{k \neq j}(p_k - c)\frac{\partial q_k}{\partial p_j}(\boldsymbol{p}) = 0.$$

Then, we define the individual demand under symmetric price by $q(P) = q_j(P, P, ..., P)$ to reduce the the first-order condition above to:

$$\frac{P-c}{P}\left[1 + \kappa(n-1)\frac{\epsilon_{cross}(P)}{\epsilon_{own}(P)}\right] = \frac{1}{-\epsilon_{own}(P)}, \quad (1)$$

where $\epsilon_{cross}(P) \equiv \frac{P}{q}\frac{\partial q_k}{\partial p_j}(P, P, ..., P) > 0$ is the equilibrium *cross* price elasticity of the individual firm's demand for any $k \neq j$.

To proceed further, the following relationship ("the Holmes (1989) decomposition") is derived:

$$\epsilon^D(P) = \epsilon_{own}(P) + (n-1)\epsilon_{cross}(P)$$

because

$$\begin{aligned} q'(P) &= \left.\frac{\partial q_j}{\partial p_j}\right|_{\boldsymbol{p}=(P,P,...P)} + (n-1)\left.\frac{\partial q_j}{\partial p_k}\right|_{\boldsymbol{p}=(P,P,...P)} \\ &= \left.\frac{\partial q_j}{\partial p_j}\right|_{\boldsymbol{p}=(P,P,...P)} + (n-1)\left.\frac{\partial q_k}{\partial p_j}\right|_{\boldsymbol{p}=(P,P,...P)} \end{aligned}$$

for any $k \neq j$. Then, Equation (1) becomes

$$\frac{P-c}{P} = \frac{1}{(-\epsilon^D)} \cdot \left(\frac{-\epsilon^D}{-\epsilon_{own}}\right) \cdot \frac{1}{1 - \kappa\frac{\epsilon_{own} - \epsilon^D}{\epsilon_{own}}},$$

which implies that

$$\frac{P-MC}{P}=\frac{\theta}{(-\epsilon^D)}. \tag{2}$$

Note that if $\kappa=1$ or $\epsilon^D=\epsilon_{own}$, then $\theta=1$: the industry is fully collusive no matter how many firms operate if $\kappa=1$. The latter is simply the case of monopoly. In contrast, if $\kappa=0$, then $\theta=\frac{\epsilon^D(P)}{\epsilon_{own}(P)}$: this converges to zero as $\epsilon_{own}(P)\to\infty$ (provided that $\epsilon^D(P)$ is bounded). In between, i.e., for $\kappa\in(0,1)$, the conduct parameter θ is decreasing in $\epsilon_{own}(P)$ and increasing in $\epsilon^D(P)$. However, its lower bound, κ, is always greater than zero.[4]

The proposition below shows the generalization of the industry model under price competition.

Proposition 1. *Under price competition with symmetric firms, the first element of the perturbed system* $(*)$ *is characterized by*

$$\Delta P=\frac{s_L\Delta w+s_K\Delta r}{1+\theta\cdot\left[1-\frac{\alpha^D+\psi}{(-\epsilon^D)}\right]}, \tag{3}$$

where $\alpha^D(P)\equiv-\frac{Pq''(P)}{q'(P)}$ *is the demand curvature,* $\psi\equiv-(1-\kappa)\frac{\left[\alpha^D-(-\epsilon^D)\right]+\left(\frac{P\cdot\epsilon_{own}'}{\epsilon_{own}}-1\right)}{(1-\kappa)+\kappa\cdot\left(\frac{\epsilon^D}{\epsilon_{own}}\right)}$ *is a parameter, and* $\frac{P\cdot\epsilon_{own}'}{\epsilon_{own}}$ *is the Kimball (1995) superelasticity of the individual firm's own demand.*

Proof. First, Equation (2) implies that:

$$\underbrace{\frac{dP}{P}}_{\equiv\Delta P}-\underbrace{\frac{wL}{PY}}_{\equiv s_L}\underbrace{\frac{dw}{w}}_{\equiv\Delta w}-\underbrace{\frac{rK}{PY}}_{\equiv s_K}\underbrace{\frac{dr}{r}}_{\equiv\Delta r}=\frac{\theta}{(-\epsilon^D)}\left[\Delta P+\Delta\theta-\Delta\epsilon^D\right]. \tag{4}$$

Now, it is observed that

$$\underbrace{\frac{d\epsilon^D}{\epsilon^D}}_{\equiv\Delta\epsilon^D}=\frac{\frac{P}{q}\cdot(q'+Pq'')\overbrace{\frac{dP}{P}}^{}\!\!\!{}_{=\Delta P}}{\epsilon^D}-\frac{\epsilon^D}{\epsilon^D}\underbrace{\frac{dY}{Y}}_{\equiv\Delta Y}$$

$$\begin{aligned}\Leftrightarrow\Delta\epsilon^D&=\frac{\epsilon^D+P\frac{P}{q}q''}{\epsilon^D}\Delta P-\Delta Y\\&=(1-\epsilon^D-\alpha^D)\Delta P\end{aligned} \tag{5}$$

because $-\Delta Y=(-\epsilon^D)\Delta P$, and that

$$d\theta=\frac{(1-\kappa)\left[\epsilon_{own}d\epsilon^D-\epsilon^Dd\epsilon_{own}\right]}{[(1-\kappa)\epsilon_{own}+\kappa\epsilon^D]^2},$$

[4] See Busse (2012) and Menezes and Quiggin (2020) for related formulations which are more aligned with Weyl and Fabinger's (2013) seminal formulation where the cause of the varying mode of competitive conduct is unspecified. In this paper, it results from common ownership between the firms.

which implies that

$$\begin{aligned}\Delta\theta &= (1-\kappa)\theta\frac{\epsilon_{own}}{\epsilon^D}\left(\Delta\epsilon^D - \Delta\epsilon_{own}\right)\\ &= (1-\kappa)\theta\frac{\epsilon_{own}}{\epsilon^D}\left[(1-\epsilon^D-\alpha^D) - \frac{P\epsilon'_{own}}{\epsilon_{own}}\right]\Delta P, \end{aligned} \tag{6}$$

Finally, we substitute Equations (5) and (6) into Equation (4) to obtain

$$\Delta P - S_L\Delta w - S_K\Delta r$$

$$= \frac{\theta}{(-\epsilon^D)}\left\{1+(1-\kappa)\theta\cdot\left(\frac{\epsilon_{own}}{\epsilon^D}\right)\left[(1-\epsilon^D-\alpha^D)-(P\epsilon'_{own}/\epsilon_{own})\right]-(1-\epsilon^D-\alpha^D)\right\}\Delta P,$$

which provides the desired result. □

This proposition shows how ΔP is divergent from the benchmark of perfect competition, $\Delta P = s_L\Delta w + s_K\Delta r$. Note first that Equation (3) becomes

$$\Delta P = \frac{s_L\Delta w + s_K\Delta r}{2-\frac{\alpha^D}{(-\epsilon^D)}}$$

if $\kappa = 1$ so that $\theta = 1$ when the industry is fully collusive to be monopoly because $\psi = 0$. This aligns with the existing literature on pass-through in monopoly (see, e.g., Adachi and Ebina 2014). In contrast, if $\kappa = 0$ when each firm maximizes its own profit only, then Equation (3) becomes

$$\Delta P = \frac{s_L\Delta w + s_K\Delta r}{1+\theta\cdot\frac{\left(\frac{P\cdot\epsilon'_{own}}{\epsilon_{own}}-1\right)}{(-\epsilon^D)}},$$

which highlights the importance of the Kimball superelasticity that arises when imperfectly competitive firms interact (see, e.g., Kimball 1995; Klenow and Wills 2016; Ritz 2020; Adachi 2020a). Recall here that the superelasticity is greater than or equal to unity if and only if the demand is log-concave. Hence, supposing that the individual firm's own demand is always log-concave ($\frac{P\cdot\epsilon'_{own}}{\epsilon_{own}} \geq 1$), it is observed that ψ is negative if the market demand is *sufficiently convex* that $\alpha^D > (-\epsilon^D)$. In this case, the role of ψ is to decrease ΔP.

However, note also that the denominator of Equation (3) is less than one if and only if the demand is *sufficiently convex* that $\alpha^D > (-\epsilon^D) - \psi$ around the equilibrium. In contrast, the denominator is greater than one if only if $\alpha^D < (-\epsilon^D) - \psi$ in equilibrium. This implies the complex nature of ψ: the elasticity, the superelasticity, the curvature as well as the common ownership interact in a non-trivial manner.

Corollary 1. *The marginal cost pass-through rate is absorbing (i.e.,* $\frac{\Delta P}{\Delta MC} < 1$*) if and only if the demand is not too convex such that* $\alpha^D < (-\epsilon^D) - \psi$*. In contrast, it is complete (i.e.,* $\frac{\Delta P}{\Delta MC} = 1$*) if and only if* $\alpha^D = (-\epsilon^D) - \psi$*, and is amplifying (i.e.,* $\frac{\Delta P}{\Delta MC} > 1$*) if and only if* $\alpha^D > (-\epsilon^D) - \psi$*.*

The role of θ is not to determine the sign, but is related to the significance of absorption or amplification: when absorption takes place, $\left|\frac{\Delta P}{\Delta MC}\right|$ is smaller for a larger value of θ. This is probably a well-known result in intermediate microeconomics; an analogy that comes from the basic fact that under monopoly with linear demand and constant marginal cost, the cost pass-through is one half. However, in the case of amplification, the opposite is true: $\frac{\Delta P}{\Delta MC}$ is *larger* for a larger value of θ. Note here that these results are expressed in terms of change in *rate, not value.*[5]

3 Analysis of the Perturbed System

Following *CPT*, this section provides both long-run and short-run analyses using the perturbed system under imperfect competition in Proposition 1.

3.1 Long-Run

We suppose that in the long-run, $\Delta r = 0$ holds. Then, given Δw, one can solve the system of four equations for four unknowns, ΔP, ΔY, ΔL, and ΔK. From the first two equations of single product industry's perturbed system, it is observed that

$$-\Delta Y = \frac{s_L \cdot (-\epsilon^D)}{1 + \theta \cdot \left[1 - \frac{\alpha^D + \psi}{(-\epsilon^D)}\right]} \Delta w,$$

which captures the *scale effect*: this measures to what extent an increase in the competitive wage, w, reduces output, Y.

Then, it is verified that

$$\begin{pmatrix} \frac{\Delta L^{LR}}{\Delta w} \\ \frac{\Delta K}{\Delta w} \end{pmatrix} = \frac{1}{1 - s_\Pi} \begin{pmatrix} -\left(s_K \cdot \sigma + \frac{s_L \cdot (-\epsilon^D)}{1 + \theta \cdot \left[1 - \frac{\alpha^D + \psi}{(-\epsilon^D)}\right]}\right) \\ \left(\sigma - \frac{(-\epsilon^D)}{1 + \theta \cdot \left[1 - \frac{\alpha^D + \psi}{(-\epsilon^D)}\right]}\right) \cdot s_L \end{pmatrix},$$

where LR stands for the long-run, $s_\Pi \equiv \frac{PY - wL - rK}{PY} = 1 - s_K - s_L$ is the profit share of aggregate product value, PY. Obviously, $s_\Pi = 0$ under perfect competition (i.e., when $\theta = 0$). Here, $-s_K \cdot \sigma$ captures *the substitution effect*, which measures to what extent an increase in the competitive wage, w, increases capital input, K.

Hence, it is verified that $\Delta w > 0$ imply $\Delta K > 0$ if and only if

$$\sigma > \frac{(-\epsilon^D)}{1 + \theta \cdot \left[1 - \frac{\alpha^D + \psi}{(-\epsilon^D)}\right]}.$$

[5] It can be verified that if quantity competition with homogeneous products is considered, the conduct parameter is given by

$$\theta \equiv \frac{1 + \kappa(n-1)}{n} \in (0, 1],$$

and that our analysis is understood as a special case of $\psi = 0$ above.

Therefore, as the intensity of competition becomes weaker (i.e., θ becomes greater),[6] it is more likely that *in the long-run, the use of capital expands ($\Delta K > 0$), ceteris paribus, in response to an increase in the wage ($\Delta w > 0$).*

3.2 Short-Run

In the short-run, capital is held fixed, $\Delta K = 0$, whereas the rental rate can change: $\Delta r \neq 0$. Now, unknown variables are ΔP, ΔY, ΔL, and Δr. Then, it is verified that

$$\begin{pmatrix} \frac{\Delta L^{SR}}{\Delta w} \\ \frac{\Delta r}{\Delta w} \end{pmatrix} = \frac{1}{\sigma \cdot s_L + \frac{(-\epsilon^D)}{1+\theta\cdot\left[1-\frac{\alpha^D+\psi}{(-\epsilon^D)}\right]} s_K} \begin{pmatrix} -\frac{1-s_\Pi}{1+\theta\cdot\left[1-\frac{\alpha^D+\psi}{(-\epsilon^D)}\right]}\cdot(-\epsilon^D)\sigma \\ \left(\sigma - \frac{(-\epsilon^D)}{1+\theta\cdot\left[1-\frac{\alpha^D+\psi}{(-\epsilon^D)}\right]}\right)\cdot s_L \end{pmatrix},$$

where SR stands for the short-run.

Therefore, $\Delta w > 0$ imply $\Delta r > 0$ if and only if

$$\sigma > \frac{(-\epsilon^D)}{1+\theta\cdot\left[1-\frac{\alpha^D+\psi}{(-\epsilon^D)}\right]}.$$

This is exactly the *same* condition for $\frac{\Delta K}{\Delta w} > 0$ in the long-run, although in general $\frac{\Delta K}{\Delta w}$ and $\frac{\Delta r}{\Delta w}$ take different values. In other words, $\Delta w > 0$ not only implies $\Delta K > 0$ in the long-run but also also results in $\Delta r > 0$ if and only if the above inequality holds, suggesting the importance of the elasticity of substitution. As in the long-run case, as the intensity of competition becomes weaker (i.e., θ becomes greater), it is more likely that *in the long-run, the rental price of capital expands ($\Delta r > 0$), ceteris paribus, in response to an increase in the wage ($\Delta w > 0$).*

4 Concluding Remarks

In this paper, we have argued that the common ownership approach to modeling imperfect competition is useful to generalize the industry model presented in Chapter 11 of *Chicago Price Theory*. It is shown that imperfect competition in the product market matters to the prediction of how the pattern of substitution between labor and capital is affected by a change in the (perfectly competitive) wage. Throughout this paper, however, we have assumed that imperfect competition exists *only in the product market*, and Δw or Δr is treated as an exogenous change as if the *labor* market as well as the *rental/capital* market are perfectly competitive. Incorporating imperfect competition into these markets ("imperfect competition in *general equilibrium*") is left for future research, and this note intends to be a small step toward this direction (but see, e.g., Azar and Vives (2021) for such an attempt).

[6] Note that this change should be interpreted as a change for a fixed value of P caused by such exogenous factors as product differentiation.

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