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Hong and Li meet Weyl and Fabinger: Modeling vertical structure by the conduct parameter approach*

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Abstract

By using Weyl and Fabinger's (2013) conduct parameter approach, this note extends Hong and Li's (2017) model of vertical structure to include downstream and upstream competition. It is shown that if the upstream sector become more competitive, the effect from markup adjustment by upstream firms, which lowers cost pass-through elasticity, is weakened *ceteris paribus*, whereas the countervailing effect that arises from the presence of downstream firms' own cost is strengthened. In contrast, cost pass-through elasticity (not the cost pass-through itself) becomes unambiguously lower if the downstream sector becomes more competitive.

Keywords: Vertical structure; Conduct parameter; Cost pass-through elasticity.

JEL classification: D43; L13.

1 Introduction

It is well recognized that cost pass-through—how the final price responds to a change in marginal cost— is important to understand the significance of a policy change such as an introduction of a "soda tax" and some other effects such as a change in exchange rate (see Ritz 2018 for an excellent survey). When a vertical relationship is considered, one also needs to distinguish between cost pass-through perceived by downstream and by upstream firms. Hong and Li (2017) empirically study how cost pass-through is affected by vertical and horizontal dimensions based on the formula for cost pass-through elasticity. Whereas the degree of vertical

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closeness—measured by product-level branding a product (i.e., whether retailer sells a national-brand product (under no vertical integration) or its own private-brand product (under vertical integration))—is captured by their methodology, horizontal competition is not fully taken into account because Hong and Li's (2017) model assumes one downstream firm and one upstream firm.

In this note, I extend Hong and Li's (2017) formula of the cost pass-through to include both downstream and upstream competition by using Weyl and Fabinger's (2013) conduct parameter approach. One of the useful features of the conduct parameter approach is that one can circumvent unnecessary complications that may arise from modeling strategic interaction directly and yet still achieves to focus on the consequences of imperfect competition. After the equilibrium retail and wholesale prices using the upstream and downstream conduct parameters are derived in Section 2, Section 3 presents a generalized version of Hong and Li's (2017) formula for cost pass-through elasticity.

Then, in Section 4, I argue that the effect from markup adjustment by upstream firms, which lowers cost pass-through elasticity (not the cost pass-through itself), is weakened if the upstream sector becomes more competitive, whereas the countervailing effect that arises from the presence of downstream firms' own cost is strengthened. This implies that the ambiguity in determining the value of cost pass-through elasticity is crucially affected by the degree of upstream competition. However, it is verified that there is no such an ambiguity as to the effect of downstream competition: cost pass-through elasticity becomes unambiguously lower if the downstream sector becomes more competitive. Lastly, I point out some limitations of this paper's approach in the end of Section 4.

2 Using Conduct Parameters to Model Downstream and Upstream Competition in Vertical Relationships

The following model is a simplified illustration of Weyl and Fabinger's (2013, pp. 562-564) setup of vertical structure.[1] Upstream firms (manufacturers) sell their products to downstream firms (retailers) with a unit price $w \geq 0$ (see Figure 1). Then, retailers successively sell these products to final consumers with a unit price $p \geq 0$. Now, suppose that each sector is represented by a single (representative) firm. The downstream firm's payment to the upstream firm is $w \cdot Q$, where Q is its sales volume as well as the order quantity. Thus, its total cost is $C^D(Q) = wQ + \widehat{C}^D(Q)$, and the marginal cost is $MC^D(Q) = w + \widehat{MC}^D(Q)$. On the other hand, the upstream firm's cost of producing Q is given by $C^U(Q)$ and the marginal cost is $MC^U(Q)$.

[1]Adachi and Ebina's (2014b) model is further a specialization of Weyl and Fabinger's (2013) setup with Cournot competition and the numbers of upstream and downstream firms being explicitly given.

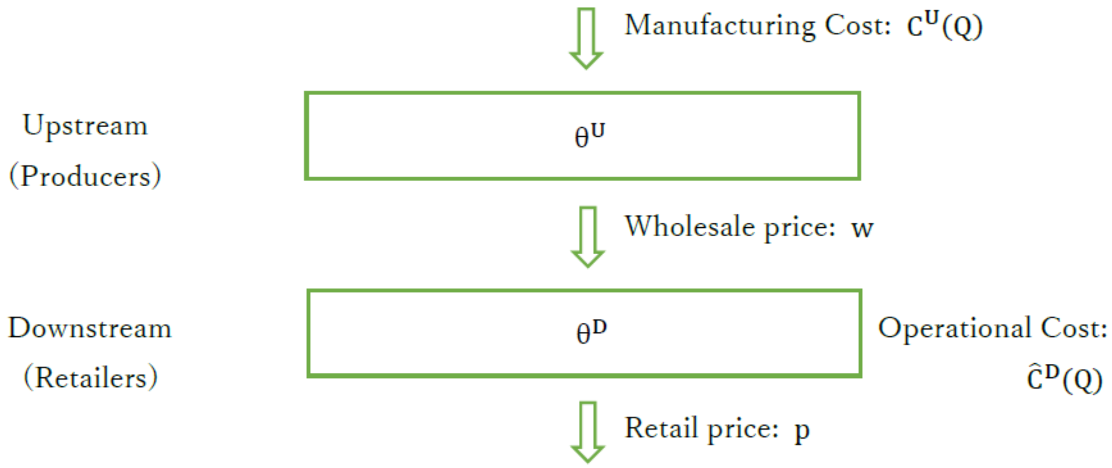

Figure 1: Vertical Structure

2.1 Downstream Equilibrium

Then, the downstream firm equates the marginal gain in profit with the marginal loss from raising the retail price p (see the left panel of Figure 2):

$$\underbrace{\theta^D(\Delta p)Q}_{\text{Maginal Gain}} = \underbrace{-\mu^D(\Delta Q)}_{\text{Marginal Loss}},$$

where $\theta^D \in [0,1]$ is the *conduct parameter for the downstream sector*, and $\mu^D \equiv p - w - \widehat{MC}^D(Q)$ is the *downstream markup*. Thus, given w, the equilibrium retail price p solves

$$\theta^D Q(p) = \{p - w - \widehat{MC}^D[Q(p)]\}\left(-\frac{\Delta Q}{\Delta p}(p)\right), \tag{1}$$

and the solution is denoted by $p = p(w;\theta^D)$. The upstream firm perceives the demand as $Q[p(w;\theta^D)] \equiv \widetilde{Q}(w;\theta^D)$. Rewriting Equation (1), I obtain the following lemma.

Lemma 1. *The downstream markup rate is given by*

$$\frac{p - w - \widehat{MC}^D[Q(p)]}{p} = \frac{\theta^D}{\epsilon^D}, \tag{2}$$

where ϵ^D is the downstream elasticity of demand: $\epsilon^D(p) \equiv -Q'(p)p/Q(p)$.

2.2 Upstream Equilibrium

Similarly, the upstream firm equates the marginal gain in profit with the marginal loss from raising the wholesale price w (now, see the right panel of Figure 2), given its perceived demand

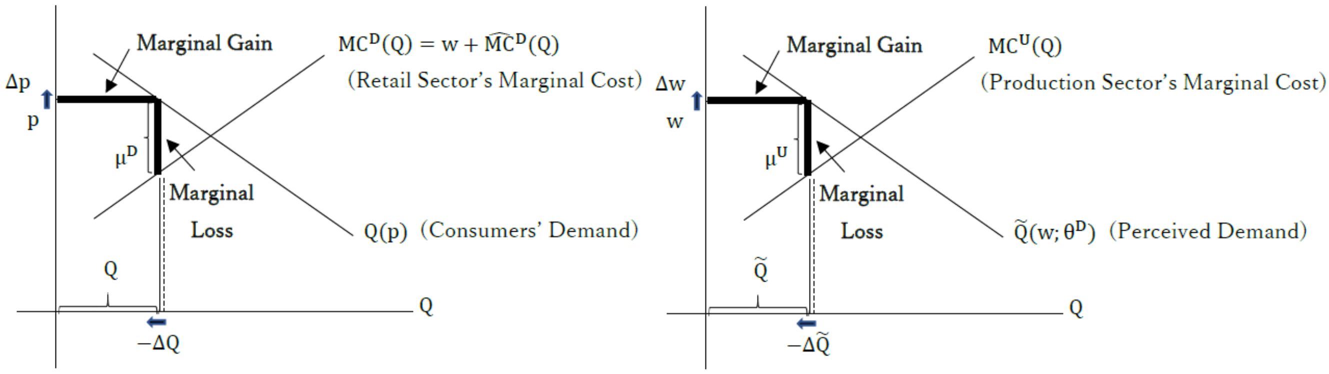

Figure 2: Downstream/Retail (Left) and Upstream/Manufacturing (Right) Layers

$\widetilde{Q}(w;\theta^D)$:

$$\underbrace{\theta^U(\Delta w)\widetilde{Q}}_{\text{Maginal Gain}} = \underbrace{-\mu^U(\Delta\widetilde{Q})}_{\text{Marginal Loss}},$$

where $\theta^U \in [0,1]$ is the *conduct parameter for the upstream sector*, and $\mu^U \equiv w - MC^U(\widetilde{Q})$ is the *downstream markup*. Thus, the equilibrium wholesale price w solves

$$\theta^U\widetilde{Q}(w;\theta^D) = \{w - MC^U[\widetilde{Q}(w;\theta^D)]\}\left(-\frac{\Delta\widetilde{Q}}{\Delta w}(w)\right), \tag{3}$$

and the the solution is denoted by $w^* = w^*(\theta^U,\theta^D)$, where

$$\frac{\Delta\widetilde{Q}}{\Delta w} = \frac{\Delta Q}{\Delta p}\cdot\frac{\Delta p}{\Delta w}.$$

Let the equilibrium retail price denoted by $p^* = p^*(\theta^U,\theta^D) \equiv p[w^*(\theta^U,\theta^D);\theta^D]$, and the equilibrium output by $Q^* = Q^*(\theta^U,\theta^D) \equiv Q[p^*(\theta^U,\theta^D)]$. Then, the following lemma obtains from Equation (3).

Lemma 2. *The upstream markup rate is given by*

$$\frac{w^* - MC^U(Q^*)}{w^*} = \frac{\theta^U}{\rho_w\epsilon^D}, \tag{4}$$

where the wholesale price pass-through elasticity is defined by $\rho_w \equiv (dp(w;\theta^D)/dw)(w/p)$.[2]

[2]See Adachi and Ebina (2014a) for an analysis of the role of wholesale pass-through in a model of successive monopoly.

3 Extending Hong and Li's (2017) Arguments by the Conduct Parameter Approach

Now, suppose that the part of additional cost for downstream distribution has a constant marginal cost for an additional unit, $\kappa^D \geq 0$ (this corresponds to θ_i^r in Hong and Li 2017, p. 152), that is, $\widehat{MC}^D(Q) = \kappa^D$. Furthermore, we assume that the marginal cost of upstream production is also constant: $MC^U(Q) = c + \kappa^U$, where $c > 0$ is the marginal cost of "commodity inputs" (Hong and Li 2017, p. 152) and $\kappa^U \geq 0$ is an additional part (this corresponds to θ_i^m in Hong and Li 2017, p. 152)). Then, Equations (2) and (4) in Lemmas 1 and 2 are simplified to

$$p = \frac{\epsilon^D}{\epsilon^D - \theta^D}\left(w + \kappa^D\right), \tag{5}$$

which corresponds to Hong and Li's (2017, p. 152) $p_i = \frac{\epsilon_i}{\epsilon_i - 1}\left(w_i + \theta_i^r\right)$, and

$$w = \frac{\rho_w \epsilon^D}{\rho_w \epsilon^D - \theta^U}\left(c + \kappa^U\right), \tag{6}$$

which corresponds to Hong and Li's (2017, p. 152) $w_i = \frac{\mu_i}{\mu_i - 1}\left(c + \theta_i^m\right)$, respectively. Thus, the equilibrium retail price is expressed by

$$p = \frac{\epsilon^D}{\epsilon^D - \theta^D}\left(\kappa^D + \frac{\rho_w \epsilon^D}{\rho_w \epsilon^D - \theta^U}\left[c + \kappa^U\right]\right).$$

This corresponds to Hong and Li's (2017, p. 153) Equation (1), where downstream and upstream competition is not considered. Now, we generalize Hong and Li's (2017, p. 153) Equation (5), which expresses the *cost pass-through elasticity*, which is defined by $\frac{dp}{dc}\frac{c}{p}$, under "arm's-length pricing" between one manufacturer and one retailer to the case of multiple manufacturers and multiple retailers.

Proposition 1. *The cost pass-through elasticity under downstream and upstream competition, where the competitiveness of the downstream and upstream layers is measured by* $\theta^D \in [0, 1]$ *and* $\theta^U \in [0, 1]$*, respectively, is given by*

$$\frac{dp}{dc}\frac{c}{p} = \frac{1}{1 + \frac{d\epsilon^D}{dp}\frac{\theta^D p}{\epsilon^D}\frac{1}{\epsilon^D - \theta^D}} \cdot \frac{1}{1 + \frac{d\mu}{dw}\frac{\theta^U w}{\mu}\frac{1}{\mu - \theta^U}} \cdot \frac{c}{c + \kappa^U + \frac{\mu - \theta^U}{\mu}\kappa^D}, \tag{7}$$

where $\mu(w) \equiv \rho_w(w)\epsilon^D[p(w)]$ *is the wholesale price pass-through elasticity perceived by upstream firms.*

Proof. With the use of Equations (5) and (6) above, it proceeds that

$$\begin{aligned}
\frac{dp}{dc}\frac{c}{p} &= \left(\frac{dp}{dw}\frac{w}{p}\right)\cdot\left(\frac{dw}{dc}\frac{c}{w}\right) \\
&= \frac{\epsilon^D}{\epsilon^D-\theta^D+(p-w-\kappa^D)\cdot(\epsilon^D)'}\cdot\frac{(\epsilon^D-\theta^D)w}{\epsilon^D(w+\kappa^D)} \\
&\quad\times\frac{\mu}{\mu-\theta^U+(w-c-\kappa^U)\cdot(\mu)'}\cdot\frac{(\mu-\theta^D)w}{\mu(c+\kappa^U)} \\
&= \frac{1}{1+\frac{d\epsilon^D}{dp}\frac{\theta^D p}{\epsilon^D}\frac{1}{\epsilon^D-\theta^D}}\cdot\frac{1}{1+\frac{d\mu}{dw}\frac{\theta^U w}{\mu}\frac{1}{\mu-\theta^U}}\cdot\left(\frac{w}{w+\kappa^D}\cdot\frac{c}{c+\kappa^U}\right),
\end{aligned}$$

where $p-w-\kappa^D=\frac{\theta^D}{\epsilon^D-\theta^D}(w+\kappa^D)=\frac{\theta^D}{\epsilon^D-\theta^D}\frac{\epsilon^D-\theta^D}{\epsilon^D}p=\frac{\theta^D p}{\epsilon^D}$ and $w-c-\kappa^U=\frac{\theta^U w}{\mu}$ are used. Lastly, it is shown that

$$\frac{1}{1+\frac{\kappa^D}{w}}\cdot\frac{c}{c+\kappa^U}=\frac{c}{c+\kappa^U+\frac{\kappa^D}{w}(c+\kappa^U)}=\frac{c}{c+\kappa^U+\frac{\kappa^D}{w}\frac{\mu-\theta^U}{\mu}w}=\frac{c}{c+\kappa^U+\frac{\mu-\theta^U}{\mu}\kappa^D},$$

which provides the desired result. □

Note that if $\theta^D=1$ and $\theta^U=1$, Equation (7) above coincides with Hong and Li's (2017, p. 153) Equation (5).

4 Discussion

Now, I discuss how Hong and Li's (2017) arguments are affected by the introduction of θ^D and θ^U. First, similar to Hong and Li's (2017, p. 153) Equation (4), the cost pass-through under vertical integration is given by

$$\frac{dp}{dc}\frac{c}{p}=\frac{1}{1+\frac{d\epsilon^D}{dp}\frac{\theta^D p}{\epsilon^D}\frac{1}{\epsilon^D-\theta^D}}\cdot\frac{c}{c+\kappa^D+\kappa^U}, \tag{8}$$

which is derived from the pricing equation under vertical integration,

$$p=\frac{\epsilon^D}{\epsilon^D-\theta^D}\left(c+\kappa^D+\kappa^U\right). \tag{9}$$

This is an extension of Hong and Li's (2017, p. 153) Equation (1) to include downstream and upstream competition.

In comparison of Equations (7) and (8), Hong and Li (2017, p. 153) point out three channels that can lower the cost pass-through under arm's-length pricing than vertical integration: (i) markup adjustment channel, (ii) cost channel, and (iii) market power channel. First, the markup adjustment by manufacturers are identified by $\frac{d\mu}{dw}\frac{\theta^U w}{\mu}$. Recall that μ measures the wholesale price elasticity of the demand perceived by upstream firms. However, this force is weakened if the upstream sector is competitive (a small value of θ^U). This is the case if the number of upstream firms is large and/or upstream firms are less differentiated. Thus, if the upstream sector is competitive, a lower cost pass-through under arm's-length pricing is less likely to occur. Second, the cost channel, which arises only if κ^D is positive, is captured by $\frac{\mu-\theta^U}{\mu}$. As the upstream sector become more competitive, $\frac{\mu-\theta^U}{\mu}$ becomes larger. As opposed to the first channel, this second channel contributes affirmatively to lowering the cost pass-through if θ^U becomes smaller. The third channel to be considered is related to the effects of vertical integration on the retail price and the market shares. It is not easy to directly compare the variables under arm's-length pricing with those under vertical integration in a meaningful way because these two regimes are inherently "discrete."

In addition, once multiple upstream firms are introduced, it is not clear how vertical integration is dealt in the conduct parameter approach. Indeed, I have circumvented modeling how a downstream firm is related to each of the upstream firms. Essentially, Equation (9) describes the situation where all upstream firms vertically integrate all downstream firms: all firms in this market become textbook firms with no vertical structure involved. Thus, θ^D no longer appears in this equation. In this setting, downstream and upstream firms are *fully separated* as decision makers, or downstream firms are *fully integrated* with upstream firms: any other intermediate situations are excluded. To connect these two "discrete" regimes in a "continuous" way, one could introduce the *Nash bargaining weight* on downstream firms, $\lambda \in (0, 1]$. Here, the case where an upstream firm has a full bargaining power ($\lambda = 0$) is excluded simply because it is equivalent to the case of ($\lambda = 1$) in terms of joint surplus, which is maximized at either $\lambda = 0$ or $\lambda = 1$. However, once λ deviates even slightly from zero, the joint surplus as a function of λ discontinuously drops, whereas it drops just continuously for $\lambda = 1 - \varepsilon$. Therefore, for $\lambda \in (0, 1]$, the variables of interest would be continuous in λ, which can also be interpreted as the *degree of vertical integration*.

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