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Germain Gaudin*

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Abstract

This paper analyzes the determinants of pass-through that are specific to vertical relationships between wholesalers and retailers. Fluctuations in input costs (due to, e.g., exchange rate shocks) are transmitted first to the wholesale price, and then to the retail price. The type of vertical agreement firms contract upon as well as their relative bargaining power are identified as major determinants of pass-through rates. The relationship between pass-through rates at the wholesale and retail levels is also investigated. Finally, the result of Bresnahan and Reiss (1985) on markup ratio is extended to the case where firms bargain over the wholesale price.

Keywords: Pass-through; Exchange Rate; Vertical contracting; Bargaining.

JEL Codes: F31; L11; L81.

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1 Introduction

A major issue in international economics is to understand the effect of exchange rate fluctuations on prices of traded goods (Engel (2002)). Exchange rate shocks are typically transmitted to prices on less than proportional increases ("incomplete pass-through"), and with a time delay.[1]

When tackling this issue in the standard model where wholesalers import goods and then contract with retailers in their local market, it is important to understand the impact of firms' vertical relations on pass-through and to identify at which level (wholesale, retail, or both) incomplete pass-through takes place. Although recent empirical findings on the relationship between pass-through at the wholesale and retail levels have been put forward by Nakamura and Zerom (2010) and Goldberg and Hellerstein (2013), for instance, there is a lack of theory work addressing this question.

In this paper, we aim at filling this gap by investigating the determinants of pass-through that are specific to vertical relationships. We highlight the relation between the type of agreement firms contract upon, their relative bargaining power, and pass-through rates. In addition, we explore the link between pass-through rates at various stages of the supply chain and the role of the slope of demand curvature. We also extend a classical result from Bresnahan and Reiss (1985) on the relationship between retail and wholesale markups to the case where firms bargain over the wholesale price.

In the literature, particular attention has been given to the role of *horizontal* market structures and functional forms of demand and supply in affecting the pass-through rate of costs to prices. This line of work was pioneered by Bulow and Pfleiderer (1983) in the case of a monopolist facing linear costs, and recently generalized by Weyl and Fabinger (2013) to various market structures and demand and cost forms. These papers have emphasized, in particular, that pass-through depends on demand curvature.

Theory work on the role of *vertical* determinants of pass-through is scarce. Bresnahan and Reiss (1985) show that when a manufacturer sets linear prices the ratio of the retailer's markup to that of the manufacturer is equal to the retail pass-through rate, that is, the rate at which wholesale prices affect retail prices. Weyl

[1] See the recent empirical evidence from, e.g., Gopinath et al. (2011).

and Fabinger (2013) extend this result to a chain of imperfectly competitive markets as an application of their main findings to vertically-related markets. Adachi and Ebina (2014a) show that the total chain pass-through rate is greater than the wholesale one if and only if demand is log-concave.[2] In these analyses, however, the authors do not investigate the impact of contract type or bargaining power on pass-through or how the retail pass-through rate compares to the wholesale one.

Theory seems thus lagging as the empirical literature used the relation between cost shocks and prices to infer vertical structure and contractual agreements (Villas-Boas (2007)), firms' relative bargaining power (Draganska, Klapper and Villas-Boas (2010)) or the use of non-linear pricing contracts and vertical restraints (Bonnet et al. (2013)).

The remainder of the paper is as follows. The basic model with linear pricing and bargaining is presented in Section 2 and solved in Section 3, provided with an extensive analysis of the results. Different contractual agreements are investigated in Section 4. Finally, Section 5 concludes.

2 Model and pass-through rates

2.1 The model

A manufacturer (or wholesaler), M, produces an input at a constant marginal cost, c, and sells it to a retailer, R, at a linear wholesale price, w. The retailer then sells at a linear price p to consumers.

Firms bargain over the linear wholesale price. We follow the classic setting of Horn and Wolinsky (1988) by considering the Nash-bargaining solution of this problem. The manufacturer has an exogenous bargaining power $\theta \in [0, 1]$, and the retailer has the remaining bargaining power $1 - \theta$. Firms can only bargain over the input price, and retail pricing is not contractible at this stage of the game.[3] The canonical Stackelberg-manufacturer setting proposed by Spengler (1950) thus corresponds to the case where $\theta = 1$. Finally, firms face no outside option to sell or

[2] In follow-up work, Adachi and Ebina (2014b) derive related results in the case of two-tier Cournot oligopoly markets.

[3] This implies (some) double marginalization under linear input pricing. However, the other contracts considered in Section 4 allow for supply chain coordination and industry-profit maximization.

buy the input, therefore both have a disagreement payoff of zero.[4]

Retail demand at price p is given by $q(p)$. We assume that demand is well defined at any price, is three times differentiable and decreasing in price everywhere over the relevant range where it is positive, i.e., $q'(p) < 0$.

Below, we will refer to the curvature of demand: $E(p) \equiv q(p)\, q''(p) / [q'(p)]^2$. Formally, the demand curvature is the elasticity of the slope of inverse demand. It takes well-identified values for common demand forms. For instance, $E = 0$ when demand is linear, $E = 1$ when it is of the negative exponential form, and $E = 1 + 1/\varepsilon$ when it displays a constant elasticity ε. In addition, a negative curvature is equivalent to the demand form being concave, and a curvature lower than unity to the demand being log-concave.

2.2 Pass-through rates

Our focus is on the determinants of three pass-through rates. The first one is the retail pass-through rate, dp/dw, which corresponds to the variation in retail price following a change in the wholesale price. The two other rates are the wholesale pass-through rate, dw/dc, and the total pass-through rate, dp/dc, which represent the impacts of a cost shock for the manufacturer on the wholesale and retail prices, respectively. In order to understand whether incomplete pass-through occurs at the wholesale or at the retail level, it is important to be able to compare the retail pass-through rate to the wholesale one.

3 Analysis

The game is solved by backward induction.

3.1 Retail pricing

In the last stage of the game, the retailer takes the wholesale price, w, as given, and sets the retail price, p. Its profit is thus given by $\pi_R = (p - w)\, q(p)$. The retailer's profit maximization problem gives the following first-order condition (omitting

[4]Because our aim is to demonstrate that pass-through may depend on firms' relative bargaining power, it is out of the scope of this paper to consider nonzero disagreement payoffs.

arguments):

$$q + (p^* - w)q' = 0 \ . \tag{1}$$

The corresponding second-order condition is equivalent to:

$$2 - E > 0 \ , \tag{2}$$

and is assumed to be satisfied everywhere over the relevant interval. Solving for the equilibrium price leads to:

$$p^* = w - \frac{q}{q'} \ . \tag{3}$$

3.2 Wholesale pricing

When firms engage in Nash bargaining, the first-stage equilibrium is determined by solving the following maximization problem:

$$\underset{w}{\operatorname{argmax}} \left\{ \pi_M^{\theta} * \pi_R^{1-\theta} \right\} \ , \tag{4}$$

where $\pi_M = (w - c)\, q$ is the manufacturer's profit and $\pi_R = -q^2/q'$ from equation (3). The first-order condition is equivalent to:

$$\theta \left(-\frac{q^2}{q'} \right) \left[q + (w^* - c)\, q' \frac{dp^*}{dw} \right] + (1 - \theta) \left[(w^* - c)\, q \right] \frac{dp^*}{dw} (-q)\, (2 - E) = 0 \ , \tag{5}$$

with the retail pass-through rate $dp^*/dw = 1/\,(2 - E)$ obtained from equation (3).

The second-order condition of the wholesale maximization problem is equivalent to:

$$(2 - E)^2 \left[1 + (1 - E)\,(1 - \theta) \right] - \theta^2 \frac{q}{q'} E' > 0 \ , \tag{6}$$

with $E' \equiv \partial E / \partial p$, and is assumed to be satisfied everywhere over the relevant interval. Solving equation (5) for w gives the equilibrium wholesale price:

$$w^* = c - \frac{q}{q'} \frac{\theta\,(2 - E)}{\left[1 + (1 - E)\,(1 - \theta) \right]} \ . \tag{7}$$

3.3 Pass-through

Implicitly differentiating these equilibrium results, we obtain the retail and wholesale pass-through rates.

Lemma 1. *Retail and wholesale pass-through rates are given by*

$$\begin{cases} \dfrac{dp}{dw} = \dfrac{1}{2-E} \ , \\[2em] \dfrac{dw}{dc} = \dfrac{(2-E)\left[1+(1-E)(1-\theta)\right]^2}{(2-E)^2\left[1+(1-E)(1-\theta)\right] - \theta^2 \dfrac{q}{q'}E'} \ . \end{cases}$$

Finally, the equilibrium retail price can be expressed as a function of c by combining equations (3) and (7) and the total pass-through rate can be obtained through the chain rule: $dp/dc = dw/dc * dp/dw$.

The comparison between both pass-through rates thus depends on three factors: demand curvature, its derivative, and firms' bargaining power. In the canonical case where $\theta = 1$, however, only the sign of the derivative of demand curvature matters:

Corollary 1. *When $\theta = 1$, the wholesale pass-through rate is strictly larger (respectively, smaller) than the retail one if and only if demand curvature locally decreases (resp., increases) in price at the equilibrium. In addition, both pass-through rates are equal when demand curvature is constant.*

This result shows that models with Stackelberg-manufacturers and constant demand curvature imply $dp/dw = dw/dc = \sqrt{dp/dc}$. Besides, the empirical literature typically observed that the problem of incomplete pass-through is more severe at the wholesale level than at the retail one (see, e.g., Goldberg and Hellerstein (2013)). This is the case, for instance, when a log-concave demand (i.e., $E < 1$) is drawn from a normal distribution (for which $E' > 0$, as shown by Fabinger and Weyl (2015a,b)) as this implies that $1 > dp/dw > dw/dc$ from Lemma 1 and Corollary 1.

In the general case, the bargaining power impacts the wholesale pass-through rate directly, and both wholesale and retail pass-through rates indirectly, through the equilibrium price and $E(p)$. When demand curvature is constant, however, this indirect channel is shut down and the direct effect at the wholesale level is given by:

$$\frac{\partial\,(dw/dc)}{\partial\theta} = -\left(\frac{1-E}{2-E}\right)\ . \tag{8}$$

In this case, the impact of bargaining power on pass-through can be summarized as follows:

Proposition 1. *When demand curvature is constant, an increase in the manufacturer's bargaining power (i) has no impact on the retail pass-through rate, and (ii) decreases (respectively, increases) the wholesale pass-through rate when demand is log-concave (resp., log-convex).*

3.4 Markup Comparison

Comparing the markups at the retail and wholesale levels from equations (3) and (7), respectively, shows the crucial role played by the retail pass-through.

Proposition 2. *Demand curvature and bargaining power determine the ratio of retail to wholesale markups* $\forall\theta > 0$*:*

$$\frac{p-w}{w-c} = \left[1 + (1-E)\,(1-\theta)\right]\frac{1}{\theta}\frac{dp}{dw}\ .$$

This shows that the ratio of both markups only depends on demand curvature and the relative bargaining power between firms. When $\theta = 1$, this ratio equals the retail pass-through rate, as demonstrated by Bresnahan and Reiss (1985). Proposition 2 shows that measures of wholesale and retail markups together with estimates of pass-through are sufficient to infer firms' bargaining power. Finally, we can replace dp/dw by the ratio $(dp/dc)\,/\,(dw/dc)$ in Proposition 2, following the chain rule, as shown by Adachi and Ebina (2014a) when $\theta = 1$.

4 Other contractual agreements

We now allow firms to contract according to agreements other than linear pricing. Of particular interest are agreements which coordinate the supply chain, i.e., which allow firms to maximize industry profits and avoid distortions due to double-marginalization. The relative bargaining power between firms then determines how they split joint profits.

More specifically, we focus on two types of agreements: two-part tariffs and revenue-sharing agreements. When these are used to maximize industry profits, the equilibrium retail price corresponds to the market monopoly price. Therefore, the total pass-through rate, dp/dc, always equals $1/(2-E)$ in equilibrium. This corresponds to the total pass-through rate of an integrated monopolist. Nevertheless, as demonstrated below, wholesale and retail pass-through rates vary according to different contracts.

4.1 Two-part tariffs

When firms use two-part tariffs, the manufacturer first sets a wholesale price, w, which the retailer has to incur for every unit bought. In addition, firms agree on a fixed-fee the retailer transfers to the manufacturer, F.

It is well-known that this contractual agreement, which is widely used in manufacturer-retailer relationships (see, e.g., Villas-Boas (2007)), coordinates the supply-chain when the variable wholesale price equals the wholesale marginal cost. Firms share the (maximized) industry profits through the fixed fee according to their relative bargaining power, denoted $\lambda \in [0,1]$ for the manufacturer.

In the joint-profit maximizing equilibrium, the input is sold at marginal cost and the retail price equals the monopoly price: $p = w - q/q' = c - q/q'$. Pass-through rates are therefore as follows.

Lemma 2. *Under two-part tariffs, retail and wholesale pass-through rates are given by*

$$\begin{cases} \dfrac{dp}{dw} = \dfrac{1}{2-E} \quad , \\ \\ \dfrac{dw}{dc} = 1 \quad . \end{cases}$$

The relative bargaining power of firms plays no role in how changes in upstream costs or input prices are transmitted to final consumers, as expressed below.

Proposition 3. *Under two-part tariffs, the retail and wholesale pass-through rates are independent of the bargaining power.*

Finally, this system of rates equals the one under linear wholesale pricing when the retailer has all bargaining power, i.e., $\theta = 0$. Therefore, as emphasized by Villas-

Boas (2007), one cannot distinguish between both types of contract by estimating pass-through rates when the bargaining power could entirely lie with the retailer.

4.2 Revenue-sharing agreements

When firms use revenue-sharing agreements, the retailer buys input at a linear price, w, and transfers a share $\alpha \in [0,1]$ of its total revenue to the manufacturer. This contract also helps firms to coordinate on maximizing industry profits by setting $w = (1-\alpha)\, c$ (see Cachon and Larivière (2005)). Firms can then share these profits through the revenue-share α which corresponds to the manufacturer's bargaining power. This type of contract is for instance widely used in the video-rental industry.[5]

In the joint-profit maximizing equilibrium, the wholesale price is thus $w = (1-\alpha)\, c$, while the retailer sets $p = w/\,(1-\alpha) - q/q' = c - q/q'$ in the second stage. Wholesale and retail pass-through rates are thus as follows:

Lemma 3. *Under revenue-sharing, retail and wholesale pass-through rates are given by*

$$\begin{cases} \dfrac{dp}{dw} = \dfrac{1}{(1-\alpha)\,(2-E)} \ , \\[2em] \dfrac{dw}{dc} = 1-\alpha \ . \end{cases}$$

Under revenue-sharing agreements, firms' bargaining power has a direct impact on both the retail and wholesale pass-through rates. This implies that the retail pass-through rate is modified when a revenue-sharing agreement is used *in lieu* of another contract, even when demand curvature is constant or when the equilibrium quantity remains stable. These relationships can be expressed as follows:

Proposition 4. *Under revenue-sharing agreements, the retail (respectively, wholesale) pass-through rate increases (resp., decreases) in the manufacturer's bargaining power.*

[5] See Mortimer (2008) for a welfare analysis of the 1998 wide adoption of such contracts in the video-rental industry.

5 Conclusion

We have investigated the determinants of pass-through at both the retail and wholesale levels of a vertically-related industry. An input cost shock is transmitted first to the manufacturer's wholesale price according to the wholesale pass-through rate. The retailer then perceives this wholesale price as its own marginal cost and passes the cost shock to consumers according to the retail pass-through rate.

The distribution of bargaining power between the manufacturer and its retailer as well as the type of agreement they contract upon are important determinants of the pass-through rates at both upstream and downstream levels. Moreover, the sign of the slope of demand curvature impacts whether the wholesale pass-through rate is smaller than the retail one.

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