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# Timing of investments and third degree price discrimination in intermediate good markets

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## HIGHLIGHTS

- Two models with different timing of investments made by downstream firms are compared.
- When investments are made after input prices are set, there is an additional indirect effect.
- The more efficient downstream firm may be charged a lower price even under linear demand.
- This is illustrated using linear market demand and quadratic investment cost.
- A higher ratio of the coefficients in the cost function implies a lower input price being charged.

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## ABSTRACT

This paper studies the discriminatory pricing of an intermediate good and compares two models with a different timing of investments undertaken by the downstream firms, before or after the upstream monopolist sets the input prices. When the more efficient downstream firm is charged a higher price than the less efficient firm in the first model, in the second model when investments are made after input prices are set, it may be charged a lower price due to the additional indirect effect of input prices on derived demands (via the change of investment incentives). It is illustrated that, with linear market demand and quadratic investment cost, whether a lower or higher price is charged to the more efficient firm depends on the ratio of the linear and quadratic coefficients in the cost function.



## 1. Introduction

Price discrimination in intermediate good markets is a widely used business practice.[1] One of the economists' concerns on input market price discrimination is that it results in a higher price charged to the more efficient downstream firm (e.g., DeGraba, 1990; Yoshida, 2000) and thus shifts production inefficiently. As we will discuss below, several papers have identified circumstances under which price discrimination may favor the more efficient downstream firm. In this paper, we focus on a factor that has attracted relatively less attention – the sequence of actions taken by the firms – and provide an alternative explanation. A key element in our analysis is the downstream firms' investment incentives which determine their production technologies but respond differently to the input prices set by the upstream monopolist under different timings.

While the Robinson–Patman act in the United States and the European Union competition law concerned primarily intermediate good markets, economic analysis of third degree price discrimination has focused largely on final good markets.[2] One of the main findings in this literature is that the monopolist should charge more in markets with lower elasticity of demand, an optimal pricing rule under third degree price discrimination (e.g. Tirole,

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[1] Even in the United States where price discrimination is prohibited under the Robinson–Patman act, there are signs that the enforcement has been loosened. Luchs et al. (2010) studied a dataset of 345 cases from 1982 to 2010 involving the Robinson–Patman act and found that the likelihood of the plaintiffs winning the cases has dropped significantly.

[2] For example, Schmalensee (1981), Varian (1985), Schwartz (1990), and more recently, Cowan (2007, 2012), Aguirre et al. (2010).

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1988). This rule also applies to the intermediate good markets and, since a lower production cost of the downstream firm implies a lower elasticity of derived demand, it leads to the more efficient firm being charged a higher input price (DeGraba, 1990). The result that a more efficient firm is handicapped under price discrimination was confirmed in Yoshida (2000) in an extension to $n$ downstream firms with different $\alpha - \beta$-*efficiency* (to produce one unit of the final good, one firm needs more of the input and incurs a higher marginal production cost). Though theoretically intuitive, it contradicts many people's understanding that, being a larger buyer, a more efficient firm should be able to get a better deal. Katz (1987) first argued that a larger downstream firm has higher ability to vertically integrate backward and consequently should be charged a lower price by the input provider. Following a similar spirit, Inderst and Valletti (2009) showed that if there is a threat of demand-side substitution the more efficient buyer receives a discount. Allowing the use of two-part tariff contracts, Inderst and Shaffer (2009) also showed that a more efficient firm obtains a lower price, amplifying differences in downstream firms' competitiveness. Li (forthcoming) noted that the upstream monopolist's pricing strategy depends on the shape of the demand curve—the more efficient firm receives a discount when the downstream firms operate in separate markets with constant elasticity demand.

Instead of exogenously assuming the downstream firms' marginal production costs, with one firm's cost higher than the other, we make costs of production endogenous by allowing the firms to choose the level of investment. By saying investment, we mean the general costly activities that can be used to lower a firm's marginal production cost. They may include, but are not limited to, R&D expenditures, managerial effort, the purchase of fixed capital, etc. One firm is more efficient than another if a lower cost of investment is incurred to reduce marginal cost to a certain level. We compare two models of a vertical relationship with a different timing of investments, before or after the upstream monopolist setting input prices. In a supplier–manufacturer type of relationship, as we name it primarily for convenience, the determination of a downstream firm's production technology usually entails large scale investment and a long time horizon, and is thus assumed to be done before the upstream firm sets input prices. For a wholesaler–retailer type of relationship, a downstream firm's marginal cost in selling products in the final market may be highly variable and easily controllable via the choice of complementary inputs such as managerial effort, inventory, shelf space, etc. In this case, the downstream firm's choice of investment level is more likely made after the input price is set and the profitability of this product is fully understood. It is worth noting that both DeGraba (1990) and Inderst and Valletti (2009) have studied the downstream firms' technology choices under price discrimination. The timing in their models would be analogous to the first model. The second model is new to the literature.

We show that if investments are chosen after the monopolist sets the input prices, a more efficient firm may end up paying a lower price than a less efficient firm even with linear final market demand (a form that has often been employed in the literature and leads to a more efficient firm paying a higher price if investments are made before input prices are set). The timing of investments plays an important role: when the monopolist sets the prices before the downstream firms invest, an indirect effect of the price of the intermediate good on the quantity demanded, through the change of the downstream firms' investment incentives, can reverse the standard result.

## 2. The Models

Consider a monopolistic upstream firm which sells an intermediate good, and two downstream firms which purchase the intermediate good and use it to produce the final good. For each unit of the final good, a downstream firm uses one unit of the intermediate good as input. Downstream firm $i$, $i = 1, 2$, incurs a constant marginal production cost. The initial level of the marginal cost is $c_0$, which can be lowered to $c_i = c_0 - x_i$ by making investment. We call $x_i$ the firm's cost reduction level, which is in one-to-one correspondence with its investment level with the following assumption. The cost of investment is $R(x_i, \theta_i)$, with $\partial R(\cdot)/\partial x_i > 0$, $\partial^2 R(\cdot)/\partial x_i^2 > 0$, and $\partial^2 R(\cdot)/\partial x_i \partial \theta_i > 0$, where $\theta_i$ measures the firm's cost efficiency. A lower value of the parameter represents higher efficiency: if $\theta_1 < \theta_2$, lowering marginal production cost to any given level would cost firm 2 more than it cost firm 1, so firm 1 is more efficient. The upstream firm's cost of supplying the intermediate good is normalized to zero.

To gain a better intuition, the derivation of the general result will be based on the assumption that the downstream firms are in separate markets,[3] whereas downstream competition is considered after specific functional forms are employed. In market $i$, consumer demand for the final good is represented by $p_i = P(q_i)$, with $P' < 0$, where $q_i$ is the final output sold by firm $i$ and $p_i$ is the market price. The demand function and the investment cost function are well behaved such that the optimization problems have their second order conditions satisfied and a unique interior solution exists.

We compare two three-stage models with different sequence of firm actions in the first two stages. For convenience of later references, the first model is called the supplier–manufacturers ($S$–$M$) model in which investments by the downstream firms are made before the upstream monopolist sets the prices of the intermediate good, $w_i$. The second model is called the wholesaler–retailers ($W$–$R$) model in which the investments are made after the prices are set. In both models, the choice of output level by the downstream firms is made in the third stage, which is characterized by the following first order condition:

$$P(q_i) + P'q_i - c_0 + (x_i - w_i) = 0. \tag{1}$$

Firm $i$'s output level depends on both its chosen cost reduction level and the input price being charged. Writing $q_i = q(x_i - w_i)$, it is easy to show that $q' > 0$, which means the firm's output level is increasing in its investment level and decreasing in the input price the upstream monopolist charges.

Due to the similarity to models in previous papers, the $S$–$M$ model will serve as our baseline model. Li (forthcoming) has shown that, given the downstream firm's marginal production cost, the upstream firm will set $\partial w_i/\partial c_i \leqslant 0$ in stage two if

$$2P' + 4P''q_i + P'''q_i^2 \leqslant 0. \tag{2}$$

Linear demand, the widely used functional form in the literature, satisfies this condition with strict inequality so the lower-cost downstream firm is handicapped. But it can be shown that such handicapping will only be partial,[4] so it is still the more efficient downstream firm that chooses a lower-cost production technology.

[3] Segmentation of the final good industry can be due to geographical barriers. Inderst and Valletti (2009) argued that geographic market segmentation is particularly relevant in Europe. Verboven (1996) studied the European car market and found that international price discrimination accounts for an important part of the price differences across European countries. Even within a national market, for many industries, different localities can be regarded as separate markets and a single downstream firm may be selected to serve consumers in that region.

[4] Or else, there would be no incentive for the downstream firms to undertake any investment in the first stage. Mathematically, from the first order condition for the upstream firm's maximization problem, we have $\frac{\partial w_i}{\partial x_i} = \frac{-q' + q'' w_i}{-2q' + q'' w_i} = 1 + \frac{q'}{-2q' + q'' w_i} < 1$.