

# Workers' Skills and Product Selection

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## Abstract

When the production of high quality goods needs the employment of qualified labour, firms' decisions concerning quality are affected by the extent to which skills are abundant. By means of a comparison between monopoly and perfect competition, we show how market power in such a context may entail a distortion in product selection towards too high average quality.

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## **Qualification de travailleurs et selection de produits**

La production d'un bien de qualité supérieure requiert l'utilisation de travailleurs spécialement qualifiés à cette fin. Quand les firmes doivent choisir la qualité des biens qu'elles se proposent de produire et de vendre, leur choix dépend de l'abondance de travail qualifié offert sur le marché du travail. Nous analysons dans cet article comment s'opère la selection de la qualité des produits par un monopole et en concurrence, en fonction de l'offre de travail qualifié. Nous démontrons que l'existence d'un pouvoir de marché introduit un biais par rapport à la solution concurrentielle, en faveur d'une qualité moyenne trop élevée.

## 1. Introduction

When a firm selects its product variant, it is bounded to choose it among those that can be manufactured, given the volume and the composition of the labour force in terms of available qualifications. Exactly as it is impossible to produce, under autarchy, a good made of a metal not available in the home country, it is as well difficult to manufacture highly sophisticated goods in a country poorly endowed with sophisticated human capital. In a world where physical capital is increasingly mobile, it is human capital that becomes more and more often a crucial factor limiting firms' production possibilities and countries' chances of development. This view is largely supported by empirical evidence. In cross- country comparisons, for instance, it is well documented that countries less endowed with "vocational" skills, such as Britain or Ireland, tend to produce goods of a lower average quality compared with countries where the labour force benefits from abundant vocational training, such as Germany or the Netherlands (Daly et al. (1985), Steedman and Wagner (1987, 1989), Hitchens et al. (1991), Mason et al. (1996)). Similarly, in time series analyses, a positive relation between the quality of products and the quality of the workforce has been found (see Abowd et al. (1996) for an analysis relative to France). Consistently, it also emerges that those countries that are relatively well endowed with skilled labour tend to perform better in higher quality segments in vertically differentiated intra-industry trade (Courakis (1991), Webster (1987), Oulton (1996), Fontagne et al., (1997), Greenaway and Torstensson (1998)).

In spite of substantial existing empirical work focused on the relationship between workers' skills and product quality, the relevance of this link for the problem of product selection on the part of firms has so far been neglected.<sup>1</sup> In a companion paper, we addressed this issue focusing on possible indeterminacies arising under firms' strategic interaction (Gabszewicz and Turrini (1998)). There, we show how the supply of product quality and specific human capital may be indeterminate when a technical linkage going from skills to quality coexists with a market linkage relating the quality configuration chosen by firms to the demand for skilled labour.

In this paper, we want to highlight a different issue, namely, that of the optimality of the equilibrium quality configuration arising under alternative assumptions concerning market structure. In doing that, we develop the simplest example of an industry characterized by a technical relation between workers' skills and product quality. Two types of labour, exchanged on perfect markets,

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<sup>1</sup>Theoretical work concerning workers' skills and product quality has so far mainly explored macroeconomic issues (see, for instance, Stokey (1991), Acemoglu (1994), and Redding (1996)).

are present within the industry: skilled and unskilled. Skilled workers are identified by their superior performance in manufacturing: they produce variants of the good of a higher quality. Since we focus on the short-run and consider industry-specific skills, we consistently assume the supply of skilled labour to be fixed and that of unskilled labour to be perfectly elastic. As for demand, we borrow from Mussa and Rosen (1978) a representation of demand that allows for goods' vertical differentiation. In such a minimal framework, we compare the properties of the equilibrium configuration emerging under two polar cases: monopoly and perfect competition. In both cases, firms are assumed to select the distribution of their sales across quality variants.

Our analysis shows that, while the quality configuration arising under pure competition is socially optimal, the one emerging under monopoly is generally not. The monopolist's incentive to supply low-quality variants of the good appears to be too weak. In other terms, market power seems to induce a bias towards a *too-high* average product quality.

## 2. The industry

Consider an industry characterized by a linear production technology: one unit of product requires one unit of labour. Assume further that two types of labour are available for production, skilled and unskilled. If skilled labour is employed, a corresponding amount of "high-quality" goods are produced (variant  $h$ ); if it is unskilled labour to be used in the production process, goods of a "low-quality" variant are obtained (variant  $l$ ). Skills are industry-specific.<sup>2</sup> We assume, consistently, that unskilled workers perform equally well in the rest of the economy, while the skilled exploit their superior abilities only in the industry under analysis.<sup>3</sup> Focusing on the short-medium run, the supply of type  $h$  labour can be taken as fixed and equal to  $L$ : skill is a scarce factor. Conversely, the supply of unskilled labour is necessarily more elastic, due to intersectoral mobility. Assuming perfect mobility, the supply of skilled labour services is perfectly horizontal, and its earnings are fixed at its *outside* marginal productivity, denoted by  $r$ . As for the earnings of skilled workers, they are denoted by  $w$ , and are determined by the demand generated within the industry under consideration. The labour market is assumed to be perfectly competitive.

Demand for the product is expressed by a continuum of consumers differing in terms of their intensity of preferences for quality (Mussa and Rosen (1978)).

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<sup>2</sup>Imagine, for instance, that skilled workers are those that benefit from vocational training in the particular production process considered.

<sup>3</sup>So, skilled workers may as well work as unskilled, while the reverse is not possible.

Each consumer, if buys, buys at most one unit of the good. Denoting by  $u_i$ ,  $i = h, l$ ,  $u_h > u_l$ , the different degrees of quality of the product, utility for the consumer characterized by taste for quality  $\theta$  is given by

$$U(\theta, u_i) = \begin{cases} \theta u_i - p_i & \text{when buying} \\ 0 & \text{when not buying,} \end{cases} \quad (2.1)$$

where  $p_i$  is the price of variant  $i$ . Parameter  $\theta$  is uniformly distributed, with density  $M$ , on the interval  $[0, \bar{\theta}]$ .<sup>4</sup> We limit the analysis to significant cases, where potential demand for skilled labour is higher than supply, so that  $L < M$ .

Denote by  $\theta_{h,l}$  the consumer that is just indifferent between buying one unit of variant  $h$  and by  $\theta_{i,0}$ ,  $i = h, l$ , the consumer that is indifferent between buying one unit of variant  $i$  and not buying. It is easily checked that  $\theta_{h,l} = \frac{p_h - p_l}{u_h - u_l}$  and  $\theta_{i,0} = \frac{p_i}{u_i}$ . Demands,  $D_i$ , are thus straightforwardly derived as follows when both variants are supplied on the market

$$D_h(p_h, p_l) = M (\bar{\theta} - \theta_{h,l}); \quad D_l(p_h, p_l) = M (\theta_{h,l} - \theta_{l,0}), \quad (2.2)$$

and by

$$D_i(p_i) = M (\bar{\theta} - \theta_{i,0}) \quad i = h, l \quad (2.3)$$

when only variant  $i$  is supplied.

We are interested in characterizing an industry equilibrium where prices for goods and skilled labour services are simultaneously determined and where the allocation of production across quality segments emerges endogenously from firms' maximizing behaviour. Concerning market structure, we consider, in turn, monopoly and pure competition as polar cases.

### 3. Monopoly

The monopolist, taking the wages  $w$  and  $r$  as given, maximises profits  $\pi(p_h, p_l)$  both with respect to price(s) and the quality profile of its sales, under the further requirement that the labour market clears.<sup>5</sup> Assuming that both qualities are

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<sup>4</sup>In a more general formulation, consumers would be ranked in  $[\underline{\theta}, \bar{\theta}]$ . In this case, it is possible that all consumers buy the product, i.e., the market is "covered". Setting  $\underline{\theta} = 0$  excludes this possibility. This assumption only precludes cases without significant interest, where demand or skilled labour is always lower than supply, so that  $w = r$ .

<sup>5</sup>Note that there is no sequentiality in this problem. Price determination, product selection and the clearing of all markets occur simultaneously.

sold, monopolist's profits are given by

$$\pi(p_h, p_l) = (p_h - w) D_h(p_h, p_l) + (p_l - r) D_l(p_h, p_l), \quad (3.1)$$

and the expression of prices obtained from profit maximization is the following

$$p_l^m = \frac{\bar{\theta} u_l + r}{2}, \quad p_h^m = \frac{\bar{\theta} u_h + w}{2}. \quad (3.2)$$

Assuming now that quality  $h$  or quality  $l$  only are sold, monopolists' profits are, respectively, obtained as

$$\pi(p_h) = (p_h - w) D_h(p_h), \quad \pi(p_l) = (p_l - r) D_l(p_l). \quad (3.3)$$

It is easy to verify that the optimal price in the case in which only product  $l$  (resp.  $h$ ) is sold by the monopolist has the same expression as that of  $p_l^m$  (resp.  $p_h^m$ ) as defined by (3.2).

Concerning product selection, the monopolist, at the prevailing wage rate  $w$ , compares the profits in the different alternatives computed at the optimal prices. Denote, respectively, by  $\pi^m(h)$ ,  $\pi^m(h, l)$   $\pi^m(l)$  equilibrium profits when the chosen quality profile is  $h$ ,  $(h, l)$  and  $l$ . Simple calculations show that

$$\pi^m(h) > \pi^m(h, l) \Leftrightarrow w < \frac{u_h}{u_l} r; \quad (3.4)$$

and

$$\pi^m(h, l) > \pi^m(l) \Leftrightarrow w < \bar{\theta}(u_h - u_l) + r; \quad (3.5)$$

At an industry equilibrium, the wage rate for skilled workers must be consistent with labour market clearing. Hence,  $w$  is determined by equality of demand and supply of skilled labour, noting that, if demand cannot be as high as supply, then skilled workers are paid as unskilled. Taking into account that demand for skilled labour is equal to the demand for the variant of high quality (namely,  $D_h(p_h)$ ,  $D_h(p_h, p_l)$  or zero, according as the quality profile is  $(h)$ ,  $(h, l)$  or  $(l)$ ), the corresponding equilibrium wage rate,  $w^m(h)$ ,  $w^m(h, l)$ , and  $w^m(l)$  is given by

$$w^m(h) = u_h \left( \bar{\theta} - \frac{2L}{M} \right), \quad (3.6)$$

$$w^m(h, l) = r + (u_h - u_l) \left( \bar{\theta} - \frac{2L}{M} \right), \quad (3.7)$$

$$w^m(l) = r. \quad (3.8)$$

Notice first that, as long as  $L > 0$ , expression (3.7) implies that inequality (3.5) must hold, which in turn guarantees that the profits realized by selling the low quality product only are always smaller than those obtained from selling both products simultaneously.<sup>6</sup> Hence, it is never optimal for the monopolist to specialise its production and sales at the bottom of the ladder. Further, it emerges that there is a switch in the optimal quality profile of the monopolist. When  $w$  starts to be higher than  $\frac{u_h}{u_l}r$ , the monopolist shifts from the supply of quality  $h$  only to the supply of  $(h, l)$ . Taking into account that the wage rate determined at equilibrium is a function of the supply of skills  $L$ , we can describe the optimal quality profile in relation with  $L$ . The switch in the profile of qualities supplied by the monopolist occurs at the threshold value of the skills supply given by  $L_M \equiv \frac{(\bar{\theta}u_l - r)M}{2}$ . When  $L < L_M$ , the monopolist chooses the mix of qualities  $(h, l)$ , while, for  $L$  greater than  $L_M$ , it starts being optimal to sell the high quality product only. This result is illustrated in Figure 1, where the wage rate of skilled labour is put in relation with its supply. Note that at  $L_M$  the wage rate paid to skilled workers starts being higher under the configuration  $(h, l)$ .

Insert Figure 1 about here (3.9)

#### 4. Perfect competition

The quality profile selected in perfect competition is identified by the following requirements that must hold at equilibrium: *i*) each operating firm selects the quality which provides it with the highest profit, *given prices and costs*; *ii*) equality of supply and demand on *each* market; *iii*) marginal cost pricing.<sup>7</sup> The first requirement says that high quality is chosen whenever  $p_h - w$  is strictly greater than  $p_l - r$ , and conversely for quality  $l$ .

First, we notice that, as in the case of monopoly, under pure competition the low quality variant  $l$  will never be the only one to be supplied in the market. In such a case, since prices must be equal to marginal costs, then  $p_l = r$ . As for the wage rate for skilled labour, the equality  $w^c(l) = r$  must hold, because demand for skilled workers is null in this case. Moreover, since variant  $h$  is not produced and exchanged, its demand,  $D_h(p_h^c, r)$  must be negative. According with (2.2),

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<sup>6</sup>It is easily checked from (3.6) and (3.7) that  $\bar{\theta} > 2 + \frac{r}{u_h}$  guarantees  $w^m \geq r$  in all quality configurations. Furthermore, we assume that there is room for positive equilibrium demand for quality  $l$ , so that, necessarily,  $\bar{\theta} > \frac{r}{u_l}$ .

<sup>7</sup>Marginal cost pricing is in our case a direct consequence of constant returns to scale in production.

this holds only if

$$p_h^c > r + \bar{\theta}(u_h - u_l). \quad (4.1)$$

Finally, for  $l$  being the only variant sold by firms, it must be that no producer gains from deviating, at current prices and wages, to variant  $h$ . Namely, it must be that

$$p_h^c - w^c(l) \leq p_l^c - r. \quad (4.2)$$

It is sufficient to recall that  $w^c(l) = r$  to see that (4.2) is not compatible with (4.1), so that  $l$  cannot be served alone on the market.

Assume, instead, that the quality profile  $(h, l)$  is selected at equilibrium. Then, marginal cost pricing impose  $p_l^c = r$  and  $p_h^c = w^c(h, l)$ , with  $w^c(h, l)$  denoting the equilibrium wage rate when both variants are sold. Accordingly, using again (2.2), we obtain that the demand for skilled labour,  $D_h(p_h^c, p_l^c)$  equals supply  $L$  if and only if

$$w^c(h, l) = r + (u_h - u_l) \left( \bar{\theta} - \frac{L}{M} \right). \quad (4.3)$$

Substituting  $p_l^c = r$  and  $p_h^c = w^c(h, l)$  into (2.2) we obtain that  $D_h(p_h^c, p_l^c) \geq 0$  is verified if and only if

$$r \geq u_l \left( \bar{\theta} - \frac{L}{M} \right), \quad (4.4)$$

a condition that must hold for both variants being selected at equilibrium.

Consider now the case in which  $h$  only is selected by competitive firms. Then, prices equal to marginal costs implies  $p_l^c = r$  and  $p_h^c = w^c(h)$ . Equilibrium in the labour market requires in this case that

$$w^c(h) = u_h \left( \bar{\theta} - \frac{L}{M} \right). \quad (4.5)$$

Finally, since variant  $l$  is neither produced, nor exchanged, it is needed that  $D_l(p_h^c, p_l^c) < 0$ , a condition that holds if and only if

$$r < u_l \left( \bar{\theta} - \frac{L}{M} \right). \quad (4.6)$$

Since conditions (4.4) and (4.6) are mutually exclusive, then the quality profile  $(h, l)$ , (resp.,  $(h)$ ) is selected at a competitive equilibrium if and only if

$$L \geq M \left( \bar{\theta} - \frac{r}{u_l} \right) \equiv L_C \quad (4.7)$$

(resp.,  $L < M \left( \bar{\theta} - \frac{r}{u_l} \right) \equiv L_c$ ).



As in the case of monopoly, the quality profile supplied at equilibrium switches from  $(h, l)$  to  $(h)$  as soon as the supply of skilled labour becomes larger than a threshold value. Similarly, when  $L = L_C$ , the wage rate for skilled labour starts being higher under the configuration  $(h, l)$ . Notice, however, that the threshold value  $L_C$  under perfect competition exceeds the corresponding threshold value  $L_M$  observed under monopoly. Necessarily, there exists a range of values  $[L_M, L_C]$  where variant  $l$  can be available to consumers only if the industry is competitive.

Insert Figure 2 about here (4.8)

Figure 2 illustrates this point. The equilibrium wage rate for skilled workers under monopoly and pure competition are depicted as functions of the supply of skilled labour (dashed lines refer to the case of pure competition.) What are the consequences of this difference concerning product selection? Consider the utility obtained by the marginal consumer  $\theta(p_h^c, p_l^c)$  when a perfectly competitive industry supplies the quality profile  $(h, l)$ . Since  $(p_h^c, p_l^c) = (w^c(h, l), r)$  it follows that the utility achieved by this consumer is given by

$$\frac{u_l(w^c(h, l) - r)}{u_h - u_l}, \quad (4.9)$$

which, according to (4.3) rewrites as  $u_l\left(\bar{\theta} - \frac{L}{M}\right) - r$ . This utility is positive when  $L < L_C$  and starts being negative for  $L > L_C$ . Pareto optimality requires that variants of low-quality should be produced as long as there exists at least one consumer whose utility exceeds their marginal cost of production; i.e., as long as  $u_l\left(\bar{\theta} - \frac{L}{M}\right) > r$ . But this also means that in a social optimum low-quality variants should be produced as long as  $L \leq L_C$ . The welfare implications of the observed differences concerning product selection are now evident. The monopolist produces only the high-quality variant  $h$  in the range  $[L_M, L_C]$ , while Pareto optimality would require as well the supply of the low-quality variant  $l$  in this range. This distortion is superposed to the more "classical" one associated with the fact that monopolistic prices exceed marginal costs.

## 5. Concluding remarks

It seems common place to say that the abundance and diversity of workers' qualifications should promote incentives for the production of sophisticated goods. Nevertheless, before reaching this conclusion, one must examine carefully how firms are guided, when they select their product line, by the nature of the competition they face on the product market and by the conditions at which they

hire their qualified workers on the specialised labour markets. In this paper we have illustrated how a technical link relating workers' skills to product quality may induce a bias in product selection associated with market power: imperfectly competitive firms tend to supply too high average quality.<sup>8</sup> Where does this bias come from? The explanation is to be found in the different demand for labour generated under alternative assumptions concerning market structure. In a concentrated market structure, product prices are higher compared with competition, entailing lower product demand, and thus lower derived demand for factors. Accordingly, the market value of skilled labour is also lower than at the optimum. Firms consequently pay too little to produce quality, and may find it convenient to stop producing "standard" variants of their product even when doing so may entail social losses. A crucial assumption driving this result is the lower supply elasticity of skilled labour: an assumption that is likely to be empirically satisfied as long as skills are strongly industry-specific.

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<sup>8</sup>This result contrasts with the well-known ambiguous direction of the distortion introduced by monopoly in the problem of product selection arising in more general contexts (Spence (1976)).

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