Information as a Double-Edge Sword: Implications for Food Standards and Labels

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Paper prepared for presentation at the American Agricultural Economics Association Annual Meeting, Montreal, Canada, July 27-30, 2003

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Abstract

An analytical model is developed to examine product quality labeling. Prior to labeling all consumers are willing to pay a premium for the quality characteristic but product quality cannot be observed directly. If production costs are increasing, the total quantity produced may contain a mix of products – with and without the high-valued attribute. In the pooled equilibrium demand is influenced by perceptions of the product mix. After labels are introduced the market is separated into two sectors, conventional and high-valued. The economic implications of labels are examined by contrasting welfare in the separating equilibrium with welfare in the pooled equilibrium. Under the models' maintained assumptions the conventional sector loses welfare, while producers of the high-valued product experience gains. In addition, producers of the high-valued product may have incentives to promote costly labeling despite net-welfare losses.

Introduction

There is increasing pressure on governments to mandate or enhance the use of food labels to achieve social objectives (Golan et. al, 2001). Contemporary debate and legislation surround the labeling of genetically modified foods (Teisl and Caswell, 2003), organic foods (Fetter and Caswell, 2002), dolphin-safe labeling (Teisl et. al, 2002), country of origin labeling (AMS, 2003), and farmer-owned brands (Hayes and Lence, 2002). The policy debates suggest substantial gains and losses from labeling (Golan et. al, 2001). This paper provides an analytical model to assess the welfare implications of labels that signal credence attributes.

A number of analytical models examine the welfare effects of labeling that enables consumers to differentiate products by credence attributes (Crespi and Maretee, 2001; Huffman et. al, 2002; Sedjo and Sparrow, 2002). Maintained assumptions about the industry's cost structure often lead to a characterization of the market, ex-ante labels, as either a complete "breakdown" (Crespi and Marettee, 2001) or comprised of a product which does not contain the valued credence attribute (Huffman et. al, 2002). For example, Crespi and Maretee (2001) maintain an assumption of complete market failure in the absence of public or private food safety certification. Consumers can not differentiate between safe and unsafe foods and the cost of producing unsafe foods is assumed to be less than the cost of producing safe food. Given uncertainty, problems of moral hazard, and competitive market assumptions, the market breaks down as the bad chases out the good (Akerlof, 1970). Following a similar logic, Huffman et al., (2002) characterize the ex-ante labeling situation as one in which only the GM (genetically modified) product is available. Modeling the ex-ante labeling scenario in this way leads to a familiar conclusion that net-welfare is enhanced by the introduction of labels.

The analytical model developed in this paper relaxes the constant costs of production assumption. Like Sedjo and Swallow (2002), who observe that eco-friendly production practices may co-exist with conventional production practices in the wood product sector even before eco-labels are introduced, we assume supply conditions in which some proportion of the total product may contain the high-valued credence attribute, even before the introduction of labels that signal quality differences to consumers. Unlike Sedjo and Swallow (2002), but similar to Spence (1973), our model allows perceptions of the mix to influence demand even before labels are introduced. The introduction of labels provides a new market signal which precipitates a separating equilibrium and a redistribution of gains and losses.

Under the models' maintained assumptions, welfare comparisons between the ex-ante and ex-post labeling scenario lead to a number of key insights. First, the conventional sector loses welfare while high-valued product producers gain. Second, the net-welfare effects of labeling become ambiguous and conditions exist in which producers have an incentive to introduce costly labels despite a potential for net-welfare losses. Third, the model demonstrates why welfare claims, based on studies that identify a willingness to pay for a high-valued credence attribute, can be misleading.

Model

We use a partial static-equilibrium framework to examine the market before and after the introduction of a label which differentiates products by a desired *credence attribute*. Consumers can not evaluate credence attributes, even in use (Golan et. al, 2001). The label is assumed to differentiate the product into two distinct sets – a subset defined by the label and its complement set. Thus the label is a standard grade label (Bowbrick, 1992). Anyone who uses the label must label

in accordance with a promulgated set of standards. In the discussion that follows the standard grade label differentiates the product into distinct sets, *conventional* and *high valued* (hv). Hereafter, *conventional* refers to a specific commodity or product that does not contain the credence attribute. The *high valued* (hv) product possesses the credence attribute, otherwise it is equivalent to the conventional product.

Demand

The aggregate demand curve traces out the reservation prices for each additional product quantity. The reservation price for the conventional product is an inverse function of quantity and is defined as follows:

(1) $$p_c = \gamma_0 - \gamma_2 q_c$$

where, γ_0, $\gamma_2 > 0$, and q_c is the quantity consumed of the conventional product. However, at each quantity demanded, there is premium for the presence of the credence attribute. Therefore, the demand curve that traces out the reservations prices for the high valued product is as follows:

(2) $$p_h = \gamma_0 + \gamma_1 - \gamma_2 q_h$$

where $\gamma_1 > 0$ and q_{hv} is the quantity consumed of the high valued product. The high value product demand curve slopes downward from the vertical intercept, $\gamma_0 + \gamma_1$.

In some pooled equilibria the supply conditions are such that a mix of high value and conventional produce enter the market even in the absence of a label that allows consumers to differentiate on the presence of a credence attribute. In situations where a mix of products

characterize the pooled equilibria we model consumer demand based on consumers perception of the product mix. This perception may be informed through a variety of information sources other than labels (e.g., media, informal networks). The perceived proportion of the credence product in the market mix is α, $0 < \alpha < 1$. Hence, the aggregate demand in the pooled equilibrium, p_α, is a weighted average:

(3)
$$\begin{aligned} p_\alpha &= (1-\alpha)p_c + \alpha p_h \\ &= (1-\alpha)(\gamma_0 - \gamma_2 q_c) + \alpha(\gamma_0 + \gamma_1 - \gamma_2 q_h) \\ &= \gamma_0 + \alpha\gamma_1 - \gamma_2 Q \end{aligned}$$

Supply

In this model there are two product sectors, a conventional product sector and a high valued product sector. Within each sector, firm-level production functions are constant returns to scale. However, there is at least one input (e.g. land) in the high valued sector that is inelastic in supply. Unit costs in the conventional sector may be constant or increasing. In the increasing cost scenario, the relationship between firm-level marginal cost and quantity is:

(4)
$$mc_c = \mu_0 + \mu_1 q_c$$

where, $\mu_0 > 0$ is a fixed cost component, $\mu_1 > 0$ is the slope of conventional product marginal cost.

The relationship between marginal cost and market share in the high valued product sector is

(5) $$mc_h = \delta_0 + \delta_1 q_h$$

where $\delta_0 > 0$ is a fixed cost component, $\delta_1 > 0$ the slope of marginal cost in market share.

Pooled Equilibrium

In a pooled equilibrium, demanders do not distinguish between the conventional and high valued products. An equilibrium occurs where the aggregate demand in the pooled equilibrium, p_α, equals the marginal cost established by the aggregate supply curve. The aggregate supply curve is derived by solving equations (4) and (5) for quantities supplied and adding these together to obtain total quantity supplied,

(6) $$\begin{aligned} Q &= q_c + q_h \\ &= \frac{mc - \mu_0}{\mu_1} + \frac{mc - \delta_0}{\delta_1} \end{aligned}$$

Solving equation (6) for mc results in

(7) $$mc_A = \varphi_0 + \varphi_1 Q$$

where $\varphi_0 = \dfrac{\delta_1\mu_0 + \mu_1\delta_0}{\delta_1 + \mu_1}$ and $\varphi_1 = \dfrac{\mu_1\delta_1}{\delta_1 + \mu_1}$. Equation (7) is the aggregate supply curve for the pooled good. The equilibrium Q^p is determined by setting equation (7) equal to equation (3),

(8) $$\varphi_0 + \varphi_1 Q^p = \gamma_0 + \alpha\gamma_1 - \gamma_2 Q^p$$

Rearranging,

(9) $$Q_\alpha^p = \frac{\gamma_0 + \alpha\gamma_1 - \varphi_0}{\varphi_1 + \gamma_2}$$

Equation 9 relates quantity demanded to supply, demand, and perceptions of the product mix. Total quantity consumed is inversely related to the slope of the demand curves and the costs of production . Total quantity demanded is a positively function of willingness to pay for the product and the premium for the credence attribute. In addition, quantity demanded depends on perceptions of the product mix.

In the pooling equilibrium, the marginal cost equations for the conventional and high value product are equal. Hence, the equilibrium quantity of the high value product may be solved for in terms of the quantity of the conventional product. Setting equation (4) equal to equation (5) leads to the following:

(10) $$q_c^p = \beta_0 + \beta_1 q_h^p$$

where $\beta_0 = (\delta_0 - \mu_0)/\mu_1$ and $\beta_1 = \delta_1/\mu_1$. Equation 10 explicitly identifies a positive relationship between quantities of the high and low valued product in the pooled equilibrium. Increases in the level of the high valued production imply an increase in the level of conventional production. This

falls directly from the maintained assumptions that both products are produced in the pooling equilibrium and that marginal costs are equated at equilibrium price.

The quantity of the high valued product can be derived from the following equilibrium condition:

(11) $$\gamma_0 + \alpha\gamma_1 - \gamma_2(q_h^p + \beta_0 + \beta_1 q_h^p) = \delta_0 + \delta_1 q_h^p.$$

Where, the right-hand side of equation 11 represents the pooled demand curve , identified in equation (3). However, quantity Q is replaced by adding together the equilibrium quantities of the high valued and conventional product – expressed in terms of the high valued product (as defined by equation 10). The right-hand side of equation 11 identifies the marginal cost of producing the equilibrium quantity of the high-valued product. Re-arranging equation (11) solves for

(12) $$q_h^p = \frac{\gamma_0 + \alpha\gamma_1 - \gamma_2\beta_0 - \delta_0}{\delta_1 + \gamma_2(1 + \beta_1)},$$

where the quantity of the high valued product, q_h^P, is defined in terms of supply, demand, and perception parameters. Quantity of the high valued product is inversely related to the slope of the demand curve. Increases in the costs of producing the high valued product, relative to the conventional product, also lead to reductions in the quantity of the high valued product produced. The quantity is positively related to the initial reservation price for the product and the premium for the credence attribute. Moreover, the quantity of the high valued product consumed depends on on perceptions of the product mix.

Figure 1, depicts a potential pooling equilibrium. In order to simplify the graph supply of the conventional product is assumed to be elastic. Hence, the equilibrium price is set at P which equals the marginal cost of producing the conventional product, mc_c . The pooled demand curve ,p_α, intersects the aggregate supply curve, at the pooled equilibrium quantity, $\overline{Q^p}$. Because some portion of the high value products marginal cost curve lies below the equilibrium price both the conventional and the high value products are competitive. In the model's pooled equilibrium consumers are unable to differentiate any one quantity consumed but the presence of the credence attribute, due to cost conditions, is reflected in consumer perceptions of a mixed product.

Modeling the pooling equilibrium as a product mix, despite the absence of labels, seems consistent with current observations. For example, Klonsky et. al, (1998) discuss surveys, conducted by the Organic Farming Research Foundation, that identify the organic production practices without organic certification. GM and non-GM products co-exist in the market without labeling. In the absence of labeling, the product mix depends mainly on assumptions made about the marginal cost of producing the conventional and high product. In Figure 1, the total quantity is identified by $\overline{Q^p}$; q_h , is the level of the high valued product and $q_c = \overline{Q^P} - q_h$.

Dead-Weight Loss of Uninformed Perceptions

Consumers perception of the product mix determines the pooled demand, p^p . However, in some situations consumers may be misinformed about the relative mix of the product quality supplied. When this occurs resources will be mis-allocated and a dead-weight loss results. Figure 2 characterizes a situation in which consumers perceive the proportion of high valued products to be greater than the actual product mix. In this situation consumers over-allocate resources to the

product and purchase Q_α rather than Q_λ . Where Q_λ is the equilibrium quantity that would be consumed under correct perceptions of the market mix and Q_α is the quantity consumed when perceptions are mistaken. Some of this over-allocation benefits producers (represented by the striped area) but the triangle ABC represents a dead-weight loss – Pareto improvements are foregone.

In this situation information about the correct product mix can lead to welfare improvements. For example, let $\lambda = q_c^p/Q^p$ be the actual share of the conventional produce in the market. Also, let Q_λ^p, be the equilibrium quantity when consumers correctly perceive the mix of products in the market. Then compared to an initial, uninformed equilibrium, the benefit of informing consumers is:

(13) $$\Delta_I = 0.5(Q_\alpha^p - Q_\lambda^p)^2(\gamma + \frac{\delta_1\mu_1}{\delta_1 + \mu_1})$$

where the Δ_I is positive because, Q_α^p is increasing in α, Q_λ^p is less than Q_α^p and $\alpha > \lambda$.

The dead-weight loss of uninformed perceptions raises three points. First, providing information about the existing product mix can improve welfare and therefore, extension efforts designed to inform consumers about agricultural production practices can be beneficial. Second, information has distributive implications. In the example described by figure two, producers benefit from consumers incorrect perceptions about the proportion of the produce with the credence attribute. On the other hand, producers will be hurt when consumers under-estimate the proportion of the market share with the credence attribute. Finally, the benefits of a labeling institution will depend, in part, on the extent to which consumers ex-ante perception of the market share is correct.

Separating Equilibrium

The introduction of labels allows producers to signal credence attributes to consumers. The signals created by many labels implicitly define a complement set. For example, organic foods implicitly define the conventional sector as non-organic. Pesticide 'free' implicitly defines the complements set as that set of goods which contain some level of pesticide. The complementary relationship between a labeled good and a non-labeled good suggests consumers valuation of the labeled product simultaneously involves consideration of the conventional good. Therefore, the new equilibrium in the labeled and non-labeled markets are interdependent. This interdependency is made explicit in the separating equilibrium – an equilibrium which identifies quantities of consumption and production, in both the high valued and conventional sector, where neither producers or consumers have an incentive to alter their production or consumption choices.

The switching point equilibrium is defined where:

(14) $$p_{hv}(q_h^s) - mc_h(q_h^s) = p_c(q_h^s) - mc_c(q_c^s),$$

and

(15) $$p_c(q_c^s | q_h^s) = mc(q_c^s).$$

Equation 14 identifies the switching point, where the marginal benefit of consuming the last quantity of the new product is equal to the marginal opportunity cost of foregoing consumption of the conventional product. Equation 15 states that the marginal benefit of the last unit of the conventional good consumed must equal the marginal cost of producing that unit.

Figure 3, provides a graphical illustration of the equilibrium conditions. Again, the graphical representation is simplified by assuming an elastic supply in the conventional sector. Thus, the equilibrium price in the conventional sector is set at p_c^*. Reservation willingness to pay for each the high valued and conventionally valued product is characterized by the downward sloping demands, p_h^s and p_c^s. (As a point of reference, to the pooling equilibrium, p_h^s and p_c^s lie above and below the pooled willingness to pay , p_α^p, respectively.) At prices P_h^* and P_c^* the switching point defined by equation 14 is graphically identified. At this point the marginal benefits of consuming the high valued product are just equal to the marginal cost of forgone conventional consumption of the conventional good. Graphically speaking, the vertical distance points A and B are equal to the vertical distance between points C and D. High valued consumption (quantity to the left of the switching point in figure 3) occur where the benefits of high valued consumption, $p_n(q_n^s) - mc_n(q_n^s)$, exceed the foregone benefit of conventional consumption, $p_c(q_n^s) - mc_c(q_c^s)$.

After the switching point equilibrium consumption in the conventional sector continues until the marginal benefits of conventional consumption equal the marginal costs. This point is identified by equation 15. In figure 3 this point occurs at $\overline{Q}$. The separating equilibrium occurs at prices P_h^*, P_c^* and respective quantities q_h, $\overline{Q} - q_h$. At these points neither producers nor consumers have additional incentives for production or consumption.

Equations 14 and 15 can be used to solve equilibrium quantities of conventional and high valued products. In terms of the linear demands and supplies, equation 15 is re-written so that the

quantity in the conventional market is stated in terms of the quantity produced in the high valued market.

(16)

$$q_c^s = \frac{\gamma_0 - \mu_0}{\mu_1 + \gamma_2} - \frac{\gamma_2}{\mu_1 + \gamma_2} q_h^s$$
$$= a_0 + a_1 q_h^s$$

where $a_0 = (\gamma_0 - \mu_0)/(\mu_1 + \gamma_2)$ and $a_1 = -\gamma_2/(\mu_1 + \gamma_2)$. Note that equation (15) implies that the conventional product decreases as the new product increases. The quantity of the new product in the separating equilibrium can be found by substituting equation (16) back into equation (14):

(17)

$$q_h^s = \frac{\mu_0 + \mu_1 a_0 + \gamma_1 - \delta_0}{\delta_1 - \mu_1 a_1}$$
$$= \frac{(\gamma_0 + \gamma_1 - \delta_0) - (\gamma_0 - \mu_0 - \mu_1 q_c^{q_h=0})}{\delta_1 - \mu_1 a_1}$$

where $q_c^{q_h=0} = (\gamma_0 - \mu_0)/(\gamma_2 + \mu_1)$, so the numerator of the last line of equation (17) is the marginal net surplus for the new product at zero minus marginal net surplus for the conventional product when no high valued product is produced. Hence the quantity of the high valued product produced is positively related to its initial net surplus and inversely related to the net surplus associated with the conventional product.

Model Implications

In this section, we examine a number of key insights that the model illuminates. First, the model identifies a number of distributional issues that may result when labels are introduced to

identify credence attributes to consumers. Specifically, under the model's assumptions, we argue that high valued producers are made better off while consumers who remain in the conventional market are made worse off. Thus, the new information generated by labels acts as a double-edge sword – helping some and hurting others. Second, the model has implications for examining the net-welfare effects of costly and costless labeling. We discuss a situation in which producers have an incentive to promote and pay for labels despite the possibility that it leads to negative welfare effects. In addition, the model identifies the potential shortcomings of using willingness to pay studies, or general preference studies, as the primary basis for advocating labeling. Finally we re-emphasize the important role that perceptions play when the pooling equilibrium product can be characterized as a mixed product.

Figure 4, illustrates the double-edge sword for a scenario in which we assume supply for the conventional product is perfectly elastic. In Figure 4 the introduction of labels leads to equilibrium prices of P_h, for the high valued product and P_c^* for the conventional product. Under the assumption of elastic conventional supply, the price for the mixed product in the pooling equilibria is equivalent to the conventional price in the separating equilibrium. Producers of the high valued product clearly gain. This may explain, in part, why standard grades are often advocated by producer groups of the high valued product (e.g., the organic industry petitioned U.S. Congress to standardize the use of the word organic). The gain to high valued producers, relative to the pooling equilibrium, is represented by the shaded region $P_h BHP_c^*$.

Conventional consumers lose surplus in this situation. Prior to the introduction of labels this group of consumers paid P_c^* for the mixed product. In the separating equilibria this group of consumers pays the same price, P_c^*, but consumes the pure conventional product only. In addition, some demand exits the sector entirely. In figure 4 this loss of surplus is represented by the area $ICFJ$. The points I and J represent points on the pooled demand curve that existed prior to labeling. The loss of consumer surplus results because this demand can no longer be realized; Oddly enough, when labeling implicitly defines its complement set, a missing market for the pooled product results and the conventional sector is worse off.

Examining this situation in close detail may help explain why the set of consumers made worse off by labeling are unlikely to voice concerns about labeling. In the model, this set of consumers has the same premium for the high valued product as the group who actually consumes them. However, once the cost of obtaining the labeled product is taken into consideration this group consumes the pure conventional good. This subset of consumers prefers the mixed product, at the pooled price, but this product no longer exists. Prior to labeling, these consumers are only aware of the premium they are willing to pay for the conventional good; They do not anticipate changes in the product price. Hence, ex-ante the label some consumers only know the premium they would pay for the high valued product. For some set of consumers, failure to consider the cost of the high-valued product may lead to a failure to recognize the primary implication of the label to them – that they become consumers of the pure conventional product after labels are introduced.

The net-welfare results in the high-valued sector are less clear. As previously discussed, producers of the high-valued product gain producer surplus. Consumers on the one hand, enjoy a

marginal benefit of γ_1 for each unit of the high valued product consumed. On the other hand, high valued consumers also forgo the benefits of consuming the mixed product at the conventional price, P_c^*; a part of this loss is not directly transferred to producers because of the increasing costs of production. Figure 4 represents the resource costs of producing the high valued product, part of which represents a loss of benefits associated with consuming the mixed product which is not fully captured by the producers.

Given explicit assumptions about perceptions, supply, and demand parameters, the model can be used to simulate changes in net-welfare that result from the shift from a pooling equilibrium to a separating equilibria. Under costly labeling our model can be used to identify situations in which producers may advocate costly labels, despite the possibility that they reduce net-welfare. This situation can be developed intuitively. Re-examine figure 4 and note that producer surplus in the high value sector increases (PS+). Consumer surplus of consumers who remain in the conventional sector decreases (CS_c -). Assume that consumers in the high-valued sector gain on average (CS_h +) and there is no net gain for conventional producers. Also, assume a fixed cost of labeling equal to τ. Under these assumptions there is some τ, *where* $\tau<PS_h$, that leads to a net-welfare loss such that $PS_h + CS_h + CS_c + \tau<0$. This occurs when the loss to conventional consumers exceeds the gain to high-valued consumers.

The model also illuminates contradictions between willingness to pay surveys that identify a premium for eco-labels and organic produce (see Loureiro and Hine, 2001) and the observation that price premiums often fail to arise (Sedjo and Swallow, 2002) and that some consumers fail to purchase organic produce despite higher willingness to pay (San Jose Mercury News, 2002). First,

the model points out that price premiums that emerge in the market depend on supply as well as demand conditions in both the conventional and high valued market. When willingness to pay for a labeled product is constant across quantity demanded, the market premium allowed by labels depend on the slope of demand as well as the slopes of supply. For example, under conditions assumed by the model, the equilibrium price for the high valued depends, in part, on the relative slopes of the marginal cost curves in the conventional and high-valued sector. Specifically, the equilibrium price in the high-valued sector is inversely related to the ratio of the high-valued to conventional supply slopes.

An interesting aspect of the model is the suggestion that some market segment will not be willing to pay for the high valued product despite having the same price premium as consumers who consume the high valued product. This segment of demand is identified in figure 3 as the quantity demanded between Q_h^s and $\overline{Q}$. Over this range the marginal benefits are higher in the conventional sector than in the high valued sector. Models that identify a willingness to pay for credence attributes but fail to take into account cross-price elasticities for the conventional product may greatly over-state the benefits of labeling. Thompson (1998), notes the lack of studies based on direct observation of consumer behavior and therefore, the absence of empirical estimates of own-price and cross-price elasticities for organic produce.

Finally, the model introduced in this paper emphasizes consumers initial perceptions of the product mix. This perception is an important determinant of welfare in the pooling equilibrium and subsequently, influence the welfare effects of the switching equilibrium precipitated by labels. This has two important implications for policy. First, as discussed earlier, dead-weight losses can be avoided by providing information, other than labeling, about the character of the product mix being

consumed. The net-benefits of these programs depend on the benefits of improved corrections versus the costs of providing this information. If perceptions are incorrect and extending information about the correct product mix is costly, efficiently achieving correct perceptions is unlikely. (The marginal costs of improving perceptions are likely to exceed the marginal benefit at some point). Still, significant improvements in welfare may result from facilitating improved perceptions of the product mix. Second, in situations where perceptions are incorrect, labels have a tertiary benefit that this paper does not address explicitly. Namely, they remove dead-weight losses which characterize the pooling equilibrium.

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Figure 1 Pooled Equilibrium

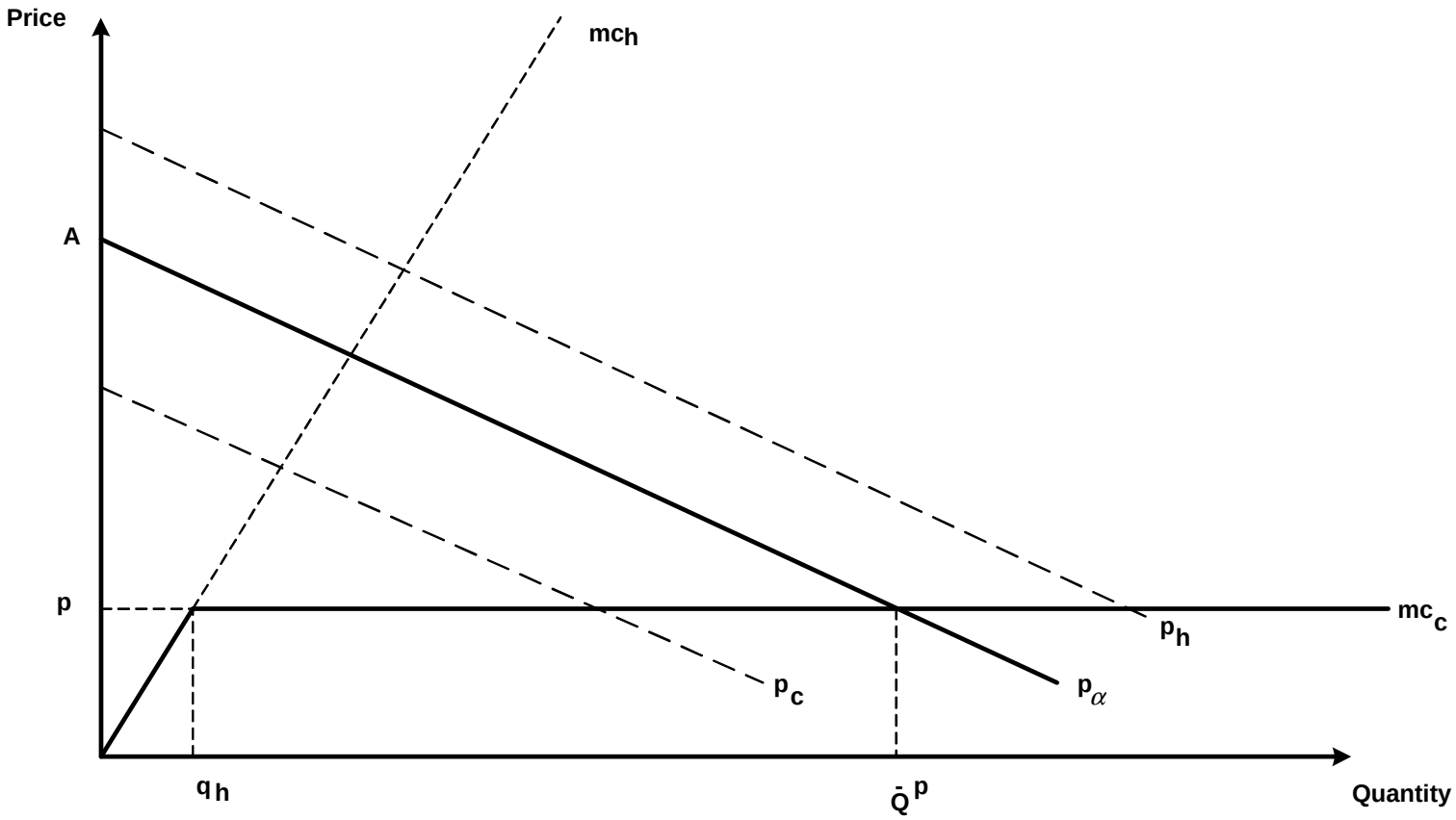

Figure 2 Deadweight Loss of Misperception

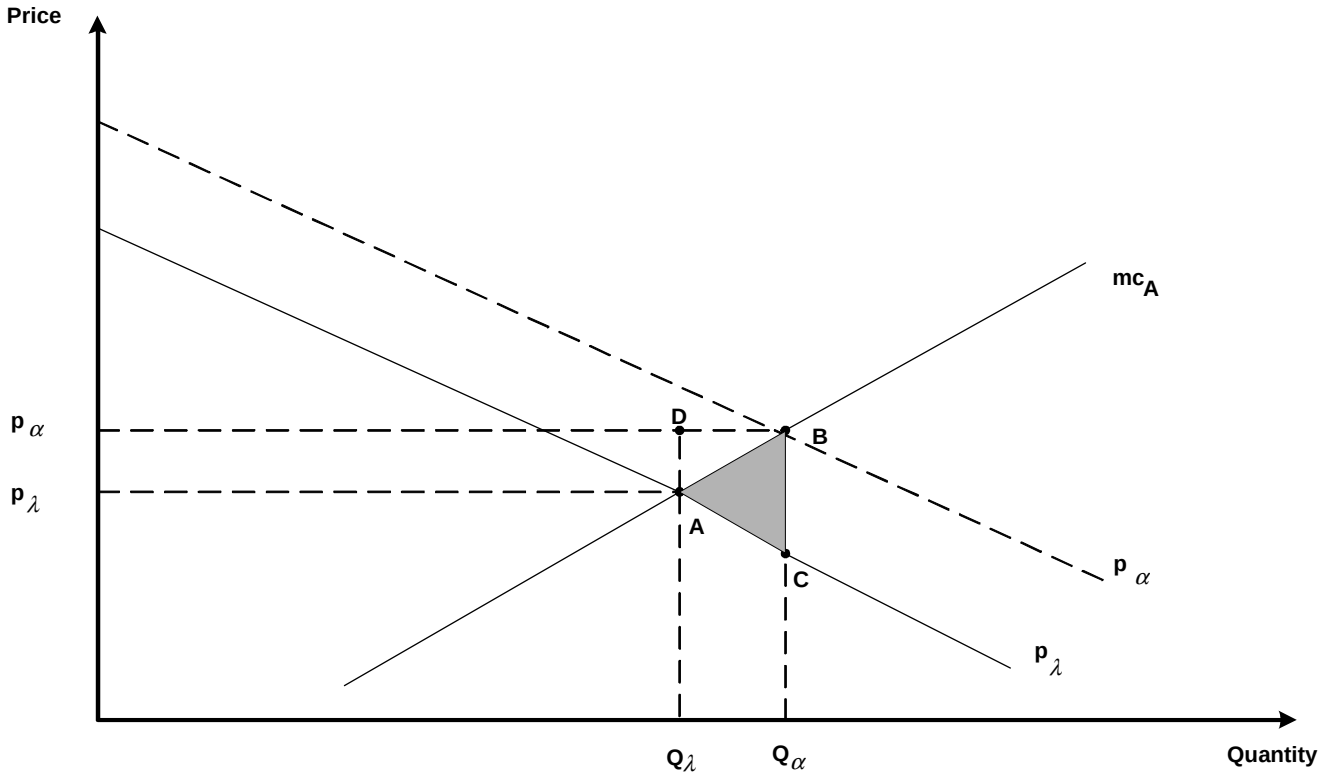

Figure 3 Separating Equilibrium

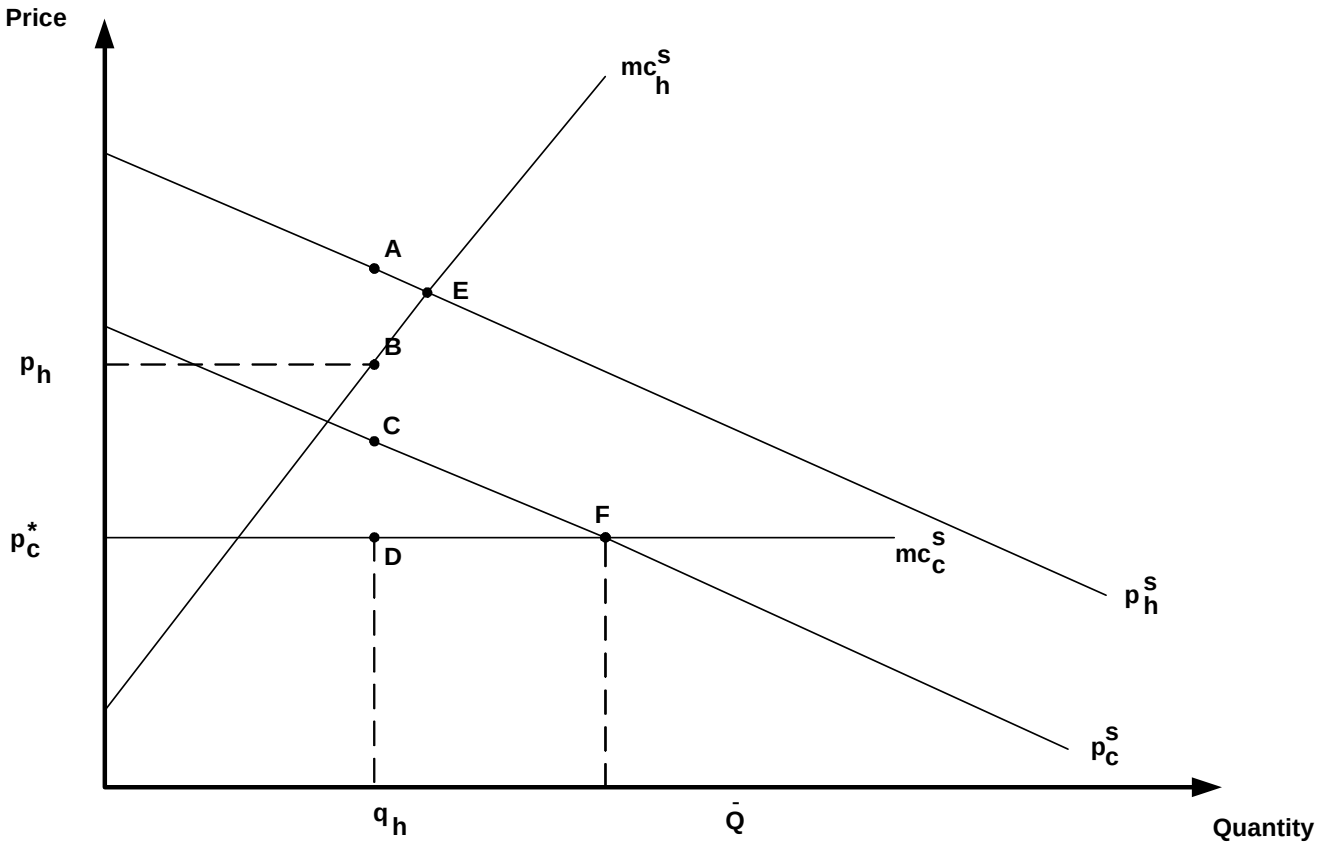

Figure 4 Double-Edge Sword