THE EFFECTS OF CONSUMER DEMAND ON REGULATION OF FOOD SAFETY

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Abstract

A model is developed where a production input contaminates food and demand responds. Control by informed consumers is compared to efficient regulation. Information changes the market failure from a health hazard among consumers to a common pool externality among producers, so that full information alone is not sufficient for efficiency.

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1. INTRODUCTION

Consumers, regulators and academics are becoming more concerned about food safety issues (Archibald, 1988; Clancy, 1988). To protect consumers from the health effects of food contamination,[1] government agencies (FDA, EPA) have designed controls on the assumption that consumers will not or cannot protect themselves. Recently, the public has become concerned about pesticides on produce, and hormones in meat and milk (Wall Street Journal, Sept. 15, 1989). Consumers have begun acting collectively to reduce marketing of contaminated foods (San Francisco Chronicle, Sept. 12, 1989). As consumers become aware of health risks and respond to them, market impacts may be large and established regulatory efforts may become inappropriate, because their underlying assumptions do not hold. The problem of food contamination has aspects of environmental externality, because producers are not paying for health costs imposed on consumers, and aspects of incomplete information, because fully informed consumers would not consume hazards without compensation. When information about contamination in food is released, consumers react, changing demand. Does this change the scope or purpose of regulation? If informed consumers control contamination through private action in the market, is there a problem? Does perfect information remove the problem and achieve efficiency?

The economic literature considers three types of solutions to product safety problems: liability, regulation and information. Because liability is not useful in food safety (because of small risks, delayed effects, and lack of evidence)

[1] Food contamination refers to production inputs, such as pesticides or antibiotics, that routinely remain in the marketed product and represent a health risk. This is unlike accidental contamination (e.g., Heptachlor in milk, Foster and Just (1985)) where regulatory options are clear.

research has focused on the choice between regulatory and informational (market-based) strategies. With the recent emergence of consumer coalitions and advocacy groups, that dichotomy cannot long be maintained. Today, regulation without information is impossible. Often, the information strategy is preferred if it can protect consumers fully. This paper examines a case where the information approach protects consumers, but is still inefficient relative to the social maximum.

Studies of the impact of a regulatory restriction (e.g., pesticide ban) tend to focus on supply effects (e.g., Archibald, et al., Lichtenberg, et al.). Studies of information and its effects on consumer reactions (e.g., food contamination scares) tend to focus on the demand side, measuring demand changes or willingness to pay (e.g., Foster and Just). Past studies have explained or measured demand responses to changes in levels of or information about food contamination (Swartz and Strand; Shulstad and Stoevener; Smith, et al.). This paper begins with this as an assumption and investigates the implications for regulatory policy.

The studies mentioned above isolate supply and demand effects to study the measurement issue at hand. When consumers respond to contamination by a production input, supply and demand are not independent. This paper considers supply and demand effects together to evaluate regulatory options. The static equilibrium where informed consumers "control" the hazard through consumption choices is compared to the equilibrium where a social planner undertakes efficient regulation. Given the marketing technology, perfect competition and a homogenous contaminated good, the actions of informed consumers achieve an inefficient solution. With perfect information, the nature of the market failure changes from a health hazard among consumers to a common pool externality among producers. There is still a role for regulation, if one goal of regulation is efficiency. One policy implication is that existing regulatory programs may not adjust rapidly enough to the changes wrought by informed consumers.

2. THE MODEL

This section develops a model of how food contamination can enter utility and hence affect demand. Throughout, consumers' actions are observed only through the demand curve. More detail is provided for producers. Assume that a production input (χ) contaminates a homogeneous final consumption good (Y), which consumers eat. Also, interior solutions are assumed; risk and uncertainty are not considered.

Demand Side

Consumers get utility from goods and disutility from contamination. To represent the exogenous health characteristics usually incorporated in demand estimation models, let the function $\theta(\chi)$ (with $\partial\theta/\partial\chi > 0$) translate contamination into health effects, which cause disutility and hence decrease demand. θ is exogenous to demand, but not to production decisions. Consumers maximize utility subject to the budget constraint, giving rise to an inverse demand curve of this form:

$$p = p(y, \theta) \; ; \quad \partial p/\partial y = p_1 < 0; \; \partial p/\partial\theta = p_2 < 0.$$ [2]

That is, θ acts as a demand shifter (e.g., as negative advertising; cf. Brown, 1969). Contamination reduces the price that consumers would otherwise be willing to pay. If the consumer is perfectly informed, then there is no health externality, because s/he consumes only if the price is low enough to compensate for the damage.

Assume that changes in θ represent actual (not perceived) health effects and there are no cumulative effects. This makes presentation simpler, although demand shifts could be caused by a combination of real and perceived effects. The parameter Θ allows introduction of information in a stylized (binary) manner: Let $\Theta=\theta(\chi,\text{Information})$. Then an informed consumer (Information = 1) knows about the contamination ($\theta(\chi,1)=\theta(\chi)$), but it is an exogenous parameter of utility. An

[2] More complete descriptions of utility that justify such demand curves can be found in Foster and Just (1985) and Brown (1989).

uninformed consumer (Information=0) is unaware of Θ in the utility function ($\Theta(\chi;0)=0$), demand is not affected, but the health hazard still exists. These simplifications are necessary because there is no concensus on how risks are perceived or on what the risks are for a given contaminant (Viscusi and Magat, Ames). Therefore, it seems appropriate to say only that utility, and demand, decline with contamination, which comes from the production technology.

Supply Side

The competitive industry producing Y consists of n identical, small, price-taking firms which produce y using χ in a constant returns technology $y=f(\chi)$ ($f_\chi>0$).[3] Producers maximize profits. Industry output is Y=ny.[4] Also, the product is marketed so that output from many producers is mixed before retail sales (e.g., milk, applesauce). Because of this marketing technology, average contamination and actual contamination are the same.

3. COMPARISON OF EQUILIBRIA

Assume the following sequence of events: Initially, consumers are uninformed, producers are unregulated, and the market is at equilibrium. Then, new research information becomes available indicating that contaminant χ is a health hazard. After information is released, the status quo is considered unacceptable because producers are using too much hazardous input, imposing health costs on consumers. Using the objective of maximizing surplus, the social planner (government agency) must choose, in the post-information state, between the informational and

[3] This is to minimize notation: For more plausiblility, assume there are other fixed inputs that are suppressed.

[4] There may be concern about χ in both functions, $\Theta(.)$ and $f(.)$. Why is Θ not a function of $n\chi$ or concentration of χ? Since $f(.)$ is CRS, usage by one producer is exactly related to total usage and concentration. $\Theta(\chi)$ indicates only that consumers react to contamination. The details can be subsumed in the function Θ. Basic results of the paper depend only on demand shifting with contamination, not on the specific structure of $\Theta(.)$.

regulatory strategies. At this point the regulator may further restrict use of χ, or use labelling and information dissemination to allow consumers to choose their desired consumption level. Since consumers are fully informed by the research announcement or the regulatory debate, the second approach is laissez faire.

In this section, equilibria are characterized and compared. Consumers can be uninformed or fully informed. Producers can be regulated or unregulated. The uninformed-regulated (UR) case must be considered transient (not an equilibrium), because the act of regulating informs consumers. This leaves three cases to examine: uninformed-unregulated (UU), informed-unregulated (IU), and informed-regulated (IR). The main effort will be to compare the two informed equilibria.

3.1 The Uninformed, Unregulated (UU) Equilibrium

Consumers have no information about contamination, so demand is unresponsive. Equilibrium occurs where consumers maximize utility and producers maximize profits independently. Utility is maximized given that Information=0 so that:

$$p = p(Y^{UU},0). \qquad (1a)$$

Each producer maximizes profits given the production function and the price:

$$\max \Pi = py - w\chi = pf(\chi) - wx$$

leading to the following first order conditions, which hold for each firm:

$$pf_{\chi}^{j} - w = 0 \qquad (1b)$$

Conditions (1) characterize the equilibrium labeled UU in Figure 1, with output y^{UU}, and surplus, W^{UU}. This equilibrium cannot be compared with the post-information equilibria, because it would require ex ante/ex post utility comparisons.

3.2 The Informed, Regulated (IR) Equilibrium

The structure of the efficient regulation equilibrium can be investigated by invoking a social planner. As noted above, the regulatory debate informs consumers. The social planner chooses χ to maximize total surplus:

$$CS + PS = {}_0\int^{y(x)} p(t,\Theta)dt - nwx.$$

The first order condition requires that:

$$\partial(CS+PS)/\partial\chi = p\partial Y/\partial\chi + {}_0\int^{y(x)} p_2(t,\Theta)\Theta_1 dt - nw = 0$$

$$p^{IR}nf_\chi + {}_0\int^{y^{IR}} p_2(t,\Theta)\Theta_1 dt = nw \qquad (2)$$

Condition (2) characterizes the informed, regulated equilibrium, labelled IR in Figure 1. Since the integral is negative by assumption, marginal revenue product (pf_χ) is greater than input price w: less χ is used than in the competitive equilibrium; supply shifts back. The planner will use a standard or a tax on producers (users of χ) to reduce use until (2) is satisfied. Also, demand shifts back from the uninformed case.[5]

3.3 The Informed, Unregulated (IU) Equilibrium

At this equilibrium, consumers and producers are both fully informed of the level of χ in the homogenous product and of its effect on demand, but use of χ is not restricted. The private first order conditions for the two groups occur where consumers maximize utility given the contaminant level. That is, they take account of the marginal disutility of health damage, but cannot affect the level of Θ:

Consumer: $$p = p(Y^{IU},\Theta(\chi^{IU},1)) \qquad (3a)$$

Similarly, producers cannot influence prices, even though demand depends in part on the level of χ, so that equilibrium occurs where:

Producer: $$pf_\chi - w = 0 \qquad (3b)$$

Equations (3) generate the solution labelled IU in Figure 1, with output y^{IU} and welfare level W^{IU}. Also, $p^{IU} < p^{UU}$ because $\Theta > 0$ implies lower demand; less Y is produced on the same supply curve.

[5] If the contaminant is completely banned, Hoehn and van Ravenswaay assume demand is unchanged after information is released, $[p(y,\Theta(\chi,0))=p(y,\Theta(0,1))]$. Even if χ is banned, however, some demand reactions may occur. Swartz and Strand found consumers avoiding shellfish after the Kepone incident, even though affected shellfish were never marketed. They termed these "spillover effects." This model allows that demand recovers only partially or that χ is only reduced not banned.

It is clear that the private information equilibrium does not equal the social equilibrium, because equations (3) do not correspond to (2). Also, it is clear that $W^{IU} < W^{IR}$, because surplus is maximized at IR: inefficiency exists at IU. More can be said about this inefficiency. There is no hazard on the fully informed consumers, because they avoid Y to the extent of damage received. However, producers still overuse χ relative to the optimum (IR), even though demand would shift out if χ were lower. This is because there is no incentive for individual producers to use less contaminant. In this market structure, producers impose a common pool externality on themselves because Y is a homogeneous product.[6] Use of χ is analogous to negative advertising. All producers together could gain by reducing χ in the final product, stimulating demand. However, individual incentives ensure that they do not. If the whole industry could collude perfectly to maximize joint profits by restricting use of χ (and Y), equation (4) would hold:

$$\text{Total Profits} = n\Pi = p(ny, \theta(\chi,1))nf(\chi) - nw\chi$$

$$\partial n\Pi/\partial\chi = [np_1 + p_2\theta_x]f + pf_\chi^j - w = 0. \qquad (4)$$

Designate the outcome of this problem Y^{joint} and p^{joint}. However, because individual producers cannot affect demand, they ignore the (negative) bracketed term and the competitive outcome is at Y^{IU} and p^{IU}, described above. From the assumptions on $p(.,.)$ and $nf(.)=Y$, we know that $Y^{joint} < Y^{IU}$, hence $p^{joint} > p^{IU}$. And since the bracketed term in (4) is negative, marginal profit is positive:

$$\partial\Pi/\partial\chi = p^{joint}f_\chi - w > 0 \ .$$

Thus, at the cooperative (joint) solution, any individual who increases χ increases profit. Since all producers face the same incentives, each overuses χ and the industry moves to the competitive outcome IU, where more χ is used than is wise for the common interest. That is, producers individually think they can gain by increasing output using more χ. But by doing so they "spoil the barrel" of the

[6] Although consumers see only average contamination, it is a common pool problem rather than a "lemons" problem because average quality is actual quality in this market structure (Akerlof, 1970).

homogeneous product and reduce demand. With this common pool problem, the market alone will not achieve the efficient outcome, even though producers are perfectly informed. Producers as a group can gain by reducing use of input χ, although for any one producer, profits must be zero in competitive equilibrium.

Ordinarily in environmental policy, producers of hazards are regulated to increase the surplus of others. Gainers should be able to compensate producers, who lose because they are forced to pay a cost that was previously free (environmental services in the case of smoke, health costs to consumers in the case of food contaminants). This has shown that it is possible for producers to gain from increased regulation. Interestingly, in this post-information, pre-regulation case, it is also possible for consumers to gain from a reduction in use of χ, even without redistribution. This can be shown by finding the effect of a decrease in input usage (χ) on consumer surplus, CS, beginning from the IU equilibrium.

$$CS = {}_0\int^{y^{IU}(\chi)} p(t,\theta)dt - p^{IU}y^{IU}$$

To find the change with respect to χ, differentiate using the Leibniz Rule:

$$dCS/d\chi = dy^{IU}/d\chi(p(t,\theta)) - d0/d\chi(.) + {}_0\int^{y^{IU}(\chi)} \partial p/\partial\chi(t,\theta(\chi))dt$$

$$- [(p_1 dy^{IU}/d\chi + p_2\theta_\chi)y^{IU} + p dy^{IU}/d\chi]$$

$$= {}_0\int^{y^{IU}} p_2(t,\theta)\theta_\chi dt - [(p_1 dy^{IU}/d\chi + p_2\theta_\chi)]y^{IU} \qquad (5)$$

$$(-) \qquad\qquad - [\ (-)(?) \ + \ (-)\ ]$$

The integral is negative because p_2 is negative. If $dy^{IU}/d\chi \geq 0$ (which seems intuitive, but may not be true if a decrease in χ stimulates a large outward demand shift), then the bracketed term ~~contains opposite signs~~ is positive and the whole expression is indeterminate in sign. Consumers gain from decreased use of χ but lose because less y is now produced at a higher price. If the reduced contamination effect outweighs the reduced quantity effect, then consumers gain (i.e., if the integral is larger than the bracketed term). If (5) is negative, then a decrease in input use will increase consumer surplus. Thus, it is possible (but not necessary) for consumers to gain at the same time as producers, with an incremental reduction in

χ starting from the IU equilibrium. However, if the expression is positive, then further control of the offensive input from this informed equilibrium, can hurt consumers (and help producers, as above), a curious result.[7]

This section showed that information is not sufficient for efficiency; there is a role for regulation. This may not be a role for government, however. What additional conditions are needed to eliminate inefficiency by market forces alone? The common pool externality among producers disappears if: the industry is monopolized; producers collude perfectly to reduce use of χ; or producers differentiate their products perfectly. However, the first "solution" introduces monopolistic inefficiency. Consumers will not suffer health externalities, but will have less product at a higher price. The collusive solution requires transactions and policing costs to be paid by producers. Also, if they can (or are allowed to) collude to reduce use of χ, they can also collude to restrict output, yielding the monopolistic solution. Government may be the appropriate agent to ensure that the pollutant is controlled, but that the producer group does not achieve market power.

Product differentiation may be a viable solution.[8] However, this requires transactions costs and the ability to police use of the label or device that distinguishes the product. Essentially then, this is a regulated outcome, where producers impose regulation on themselves. Since consumers are still harmed if product designations are false, government may be needed to control and monitor use

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[7] This discusses the merits of a marginal move away from the IU equilibrium. This is not a comparison of surplus between IU and IR, where there are likely to be tradeoffs in surplus between groups.

[8] There are legal/property rights implications, however: establishing markets for all levels of contamination and letting consumers choose seems to deny any right to clean food and does not protect the uninformed.

of the product designations (e.g., "organic", "hormone free"). Otherwise producer groups and retailers may misrepresent content.

Also, for efficiency, product differentiation to all levels of contamination must occur so that each consumer may choose the exact level of contamination s/he desires. In a stylized, frictionless world, all identical producers should immediately realize that it is in their interest to move immediately to level χ^{IR}. In the real world, however, the adjustment process will likely be slow as non-identical producers who overuse χ are forced out of the market. Also, with differentiated products, producers may become oligopolists, introducing another inefficiency. If regulation can move faster, or prevent market power, then the regulated solution may be preferred to product differentiation.

3.4 SUMMARY AND CONCLUSIONS

Summarizing the discussion in Section 3, the following relations are known:

	UU		IR		IU
OUTPUT:	Y^{UU}	>	Y^{IR}	?	Y^{IU}
INPUT/CONTAMINANT:	χ^{UU}	>	χ^{IR}	<	χ^{IU}
TOTAL WELFARE:	W^{UU}	<	W^{IR}	>	W^{IU}

It is also known that $Y^{IU} < Y^{UU}$. However, output Y^{IR} cannot be compared with Y^{IU}.

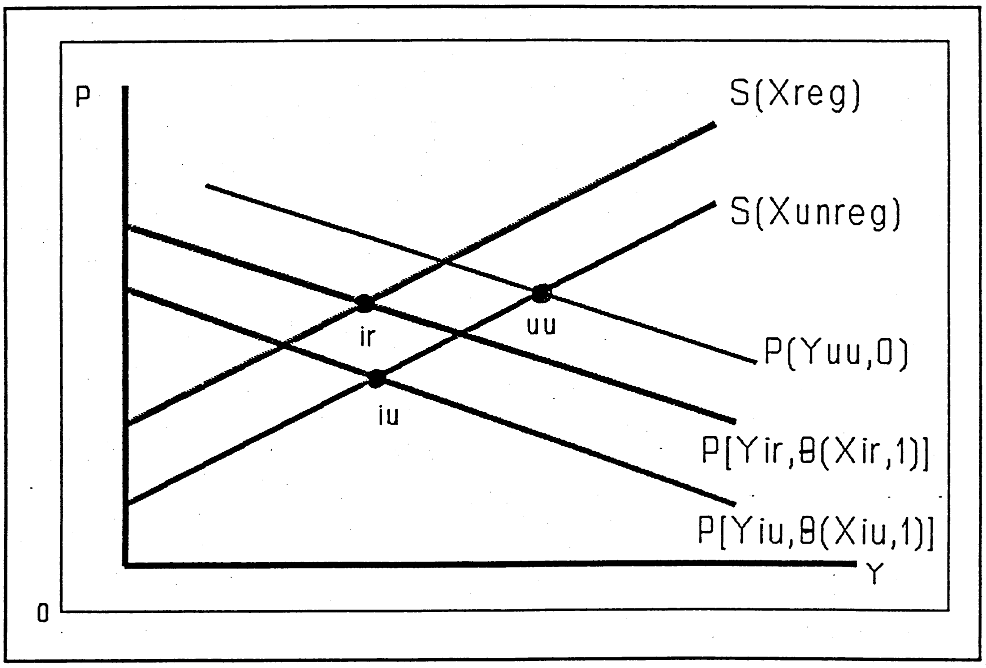

Figure 1
Equilibria Resulting from Different Information Assumptions

This model illustrated that full information alone is necessary but not sufficient for efficiency. This is because consumer action alone acts to reduce output, while the efficient solution is to reduce use of the input. Consumers can protect themselves, but cannot move the economy to the social maximum, even with full information. As long as producers decide χ myopically or without cooperation, output under information without regulation will be produced using too much χ. Additional conditions on market structure, such as product differentiation, are needed to achieve efficiency. This analysis dealt with only one market structure.

Total surplus is higher at the regulated equilibrium than at the information only equilibrium in this model. Hoehn and Ravenswaay, using an empirical model, found larger surplus at the regulated equilibrium than at the informed equilibrium. This paper's theoretical results are consistent with that finding. It is also possible that both consumer and producer surplus may increase by moving away from the informed equilibrium toward the regulated one. This is in contrast to the usual tradeoff, where gains in surplus of one group can be had only at the expense of the other group (as at the social maximum where CS'=-PS').

The mingling of supply and demand effects when consumers react to the level of contamination makes the distinction between regulatory and informational strategies less clear. The scope and purpose of regulation change after full information is achieved. Even though informed consumers are not harmed, government may want to increase efficiency by removing the common pool externality or to smooth market transitions by regulating product quality designations.

This paper considered only static equilibria. When dynamics are introduced, the regulatory program will have to account for consumers' reactions to information, level of contamination, and to the regulatory program itself. Also, the sequence of events (release of information vs. announcement of controls) will become important.

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