GRADING STANDARDS AND PESTICIDES

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Working Paper 95-12

July 1995

Chapter xx

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Introduction

Possible linkages between grading standards for fruits and vegetables and the intensity of pesticide use have been widely discussed in policy circles. Three years ago, the U.S. Senate held hearings on the linkages between grading standards and pesticide use on fruits and vegetables. Representatives from environmental organizations and food and health policy organizations similarly testified that U.S. Department of Agriculture (USDA) standards governing appearance of fruits and vegetables cause farmers to apply pesticides in cases where they otherwise would not, citing examples ranging from thrips damage on citrus to apple scab to mildew and insect parts in lettuce and celery. USDA standards were characterized as purely "cosmetic", affecting appearance rather than actual quality in consumption. Testimony at these hearings indicated that such "cosmetic" uses of pesticides are widespread. Senator Wyche Fowler of Georgia cited an Office of Technology Assessment report claiming that up to half the pesticides used in orchards were used to meet appearance standards, while 60 to 80 percent of pesticides used on California oranges were used to meet appearance standards having nothing to do with internal quality. Surveys by Public Voice and the American Farm Bureau Federation in the late 1980s and early 1990s came up with similar findings for citrus and apples (U.S. Senate Committee on Agriculture, Nutrition and Forestry 1992).

The notion that appearance standards for fruits and vegetables increases pesticide use dates back to a report written by Robert van den Bosch for the U.S. Environmental Protection Agency (EPA). That report argued that purity standards for insect parts promulgated by the Food and Drug Administration force growers to use pesticides more intensively than they otherwise would (van den Bosch et al. 1975). Comparison of trends in FDA seizures of produce for violations of standards for insect part standards and pesticide residues show an inverse relationship: The frequency of violations for pesticide residues began rising sharply at the same time that violations for insect parts fell sharply (Pimentel et al. 1977). Pimentel and Pimentel (1980) subsequently broadened this argument, targeting USDA standards for fruit and vegetable quality as providing significant incentives for intensifying pesticide use. Advocacy pieces by the Natural Resources Defense Council (Curtis et al. 1991), the Public Voice for Food and Health Policy (Rosenblum 1991) have popularized this argument.

To date, however, these claims have received little rigorous economic analysis, either theoretical or empirical. Theoretical work in particular has been almost completely lacking. Surveys by the USDA's Economic Research Service (Powers and Heifner 1991) and Agricultural Marketing Service (Conklin and Mischen 1992) and by EPA (Office of Policy, Planning and Evaluation 1992) discussed possible economic incentives but reached no firm conclusions. Empirically, Starbird (1994) analyzed the role of processor-imposed standards for tomato fruitworm on pesticide use in processing tomatoes in California. Using a simulation model, he shows that sampling error can lead growers to apply more pesticides than strictly necessary to meet the nominal standard. Babcock et al. (1992) estimated the effect of fungicide use on the percentage of North Carolina apples qualifying for fresh market sale. Their estimates suggest that quality considerations–not all of which are cosmetic–account for about 10 percent of fungicide use on North Carolina apples. Other empirical evidence has been largely anecdotal and restricted to a small number of cases. The case cited most commonly, that of citrus on thrips (which cause scarring that has no adverse effect on juiciness of flavor), was first discussed by the National Academy of Sciences in 1980. Other cases cited are less obviously cosmetic. Mildew, for example, affects spoilage and thus consumption. Limitations on insect parts may well reflect consumer notions of food sanitation.

In what follows, I describe some results from a rigorous analysis of the pesticide-use incentives created by cosmetic appearance standards. A full report of this analysis can be found in Lichtenberg (1995). Contrary to the public policy discussion, I find that tighter cosmetic standards may reduce pesticide use rather than increase it. In particular, I find that the way that standards are actually applied and how standards are used in marketing fruits and vegetables are critical in determining what effects tighter or looser appearance standards may have. I use some data from North Carolina apple production to illustrate the effects of tighter appearance standards under alternative marketing scenarios. Note that this analysis does not address the issue of whether additional pesticide usage (if it occurs) creates hazards to the environment or to the health of workers or consumers; these, too are issues in the debate that could use more rigorous analysis.

Analysis of Cosmetic Pesticide Use

Grading standards are a way of bundling characteristics of commodities that simplify the process of making transactions. USDA has grading standards for numerous commodities. The use of those grading standards is mandatory for commodities subject to marketing orders, but they are also used voluntarily in markets for other crops, including apples. Also, commodity organizations may create their own grading standards in cases where the government does not, such as coffee or cocoa. Grading standards take the form of a set of constraints on different product characteristics, specifically lower bounds on desirable characteristics and upper bounds on undesirable characteristics. In apples, for example., desirable characteristics include color (the percentage of fruit of the desired color for the varietal type) and size (minimum diameter). Undesirable characteristics include damage from weather, insects, or diseases.

How grading standards affect pesticide use turns out to depend on the way that grading standards affect marketing. There are two different ways in which grading standards can be used in marketing. First, commodities can be sold in lots of mixed quality, where part of a shipment meets grading standards and part does not. Second, commodities can be sorted and sold in lots of uniform quality, where all items in a shipment meet the grading standard, but total output is divided into different shipments according to the standards. (The same structure applies in the case where graders allow for tradeoffs among attributes in determining grade, rather than applying strict cutoffs to each attribute.) The way in which standards enter marketing arrangements is important because it determines how pesticide use affects revenue earned, and thus profit-maximizing pesticide use.

Consider for example a simple case in which a commodity has two levels of quality, high and low, determined according to government grading standards. The price of high-quality output exceeds that of low-quality output. (The price of low-quality output may be zero if the product cannot be sold, as is the case when the shipment violates FDA standards for insect parts or pesticide residues, or in the tomato fruitworm case studied by Starbird 1994.)

The fraction of output meeting the standards for high quality is an increasing, concave function of pesticide use. To focus attention on the strictly "cosmetic" case, assume that pesticide use has no effect on total output, i.e., pesticides have a quality effect, but no quantity effect. To get at the effects of grading standards, let the fraction of output meeting the standards for high quality be a decreasing function of a shifter; a higher value of this shifter represents a stricter grading standard, in that a smaller share of output qualifies as high-quality. Assume also that these standards are purely cosmetic in the sense that consumers are not willing to pay anything extra for output meeting stricter standards; formally, a change in the shifter has no direct effect on the price of high-quality output.

I begin with the case where the commodity is sold in lots of mixed quality. This case applies to Starbird's (1994) example of fruitworm in processing tomatoes. It also applies to several cases that are commonly cited in the cosmetic pesticide literature, specifically, FDA standards for pesticide residues or insect parts. In this case, all of a grower's output will be sold as high-quality if the share meeting the standard is high enough; otherwise, all output will be sold as low-quality. As a result, the marginal revenue product of pesticide use is either zero or infinite, so that the pesticide is either used at a standard application rate or is not used at all. If the grower aims to sell the commodity in the high-quality market, the profit-maximizing application rate of the pesticide is just high enough to ensure that a sufficiently large share of output meets the appearance standard, and profit will equal the profit from selling the crop as high-quality minus expenditures on the pesticide. Any application rate above the critical level does not change revenue at all, while it increases pesticide expenditures, and is thus less profitable, but any application rate below the critical level ensures that the entire crop will be sold as low-quality, since the share of output meeting the appearance standard will be too low. If the grower decides to forego the high-quality market and sell the commodity strictly as low-quality, it makes no sense to use the pesticide at all; any application rate greater than zero but less than the critical level does not change revenue but does increase pesticide expenditures and is thus less profitable than zero pesticide use. In sum, the pesticide will be used at the critical level if selling in the high-quality market is more profitable; if selling in the low-quality market is more profitable, pesticide use will be zero. (For further detail see Lichtenberg 1995.)

Making the grading standard stricter, in the sense of reducing the fraction of output qualifying as high-quality, will increase in the critical application rate and thus generally lead to increases in pesticide use. Figure 1 shows the share of total output meeting the appearance standard as a function of pesticide use. Using more of the pesticide ensures that a higher fraction of output meets the appearance standard. All output can be sold as high-quality if the fraction meeting the appearance standard is at least equal to s. The critical pesticide application rate zc is the one that ensures that the fraction meeting the appearance standard equals s exactly. Increasing the stringency of the standard corresponds to a rightward shift in the curve. After the shift, a larger pesticide application rate zc′ is needed to ensure that the fraction meeting the appearance standard equals s. If it is still more profitable to sell in the high-quality market, pesticide use will increase.

[Figure 1 here]

In this case, stricter grading standard have the effect postulated in the environmental literature on cosmetic standards, that is, stricter standards lead to greater pesticide use. But this scenario does raise a question about why commodities are marketed in this way. It seems likely that sorting output by quality and selling shipments of uniform quality in separate markets would be more profitable than selling lots of mixed quality. One plausible reason for selling lots of mixed quality is that sorting may be excessively costly. Such is the case with FDA food purity standards governing pesticide residues and insect parts, for instance: Sorting requires testing in an analytical chemistry laboratory, which is time-consuming and expensive. The tomato fruitworm example discussed by Starbird is very similar, since determining the quality of each piece requires destructive testing (cutting open each tomato).

But in the vast majority of cases, commodities more than meet FDA food purity standards; sorting involves mainly visual inspection and can thus be accomplished at reasonable cost. Grading standards affect pesticide use very differently in these cases. Suppose that the grower sorts the commodity and sells all output meeting the appearance standard in the high-quality market, while the remainder is sold in the low-quality market. In this case, pesticide use affects the share of output sold in each market, and thus the average price the grower earns. The more of the pesticide the grower uses, the greater is the share sold in the high-quality market and thus the greater is the average price earned on the crop. Profit-maximizing pesticide use is found by equating the price of the pesticide with the marginal revenue product of the pesticide, which equals output times the price differential between high- low-quality output times the increase in the share of output sold as high-quality.

Figure 2 shows the determination of optimal pesticide use in this case. Note that the second-order conditions requiring diminishing marginal revenue productivity ensure that the right-hand intersection of the pesticide price and marginal revenue product curves is the relevant one. How does increasing the stringency of the appearance standard affect the marginal revenue product of the pesticide? That turns out not to be straightforward. Increasing the stringency of the appearance standard has two effects. First, it exogenously lowers the average price of output, reducing the marginal revenue product of the pesticide and thus creating an incentive to *reduce* pesticide use. I call this the composition effect. Second, a stricter standard may change the marginal effect of the pesticide on the share meeting the standard for high quality. I call this the productivity effect. As I show elsewhere (Lichtenberg 1995), if the productivity effect is zero or negative (stricter standards do not increase the marginal effect of the pesticide on the share qualifying as high-quality), then stricter standards unambiguously lead to reduced profit-maximizing pesticide use, contrary to the claims made in the environmental literature. In this case, increasing the standard shifts the marginal revenue product curve to the left. In fact, stricter standards lead to increased pesticide use only when two conditions hold: (1) the productivity effect is positive and (2) the productivity effect is large enough to outweigh the composition effect. In this case the stricter standard shifts the marginal revenue product curve to the right.

[Figure 2 here]

In sum, the claim made in the environmental literature on the effects of appearance standards on pesticide use hold only under some rather restrictive conditions that may not characterize much of fruit and vegetable production.

Example: North Carolina Apple Production

To illustrate the theoretical analysis constructed an empirical example using data on North Carolina apple production. Babcock et al. (1992) used these data to estimate the productivity of pesticides in terms of both quantity and quality. The data include observations on orchard characteristics, weather conditions, output, use of insecticides and fungicides, quality of pruning, product quality (measured as the percentage qualifying for processing (low-quality) use only), and damage (the percentage of fruit with damage exceeding the standard for high quality due to disease, insects, and weather).

To simplify matters, I looked only at fungicide use for preventing disease damage. I estimated two equations: (1) an equation relating fungicide use and orchard characteristics to the percentage with damage exceeding the standard for high (fresh market) quality; and (2) an equation relating different kinds of damage to the percentage of output qualifying for low-quality (processing) use only. I used logistic specifications for both equations. As a baseline, I used the average price and price differential between high- and low-quality apples reported by Babcock et al. (1992), \$200 per ton and \$317 per ton, respectively. I set the elasticity of supply for apples equal to 0.4. (Details can be found in Lichtenberg 1995.)

For the mixed-quality case I calculated the critical level of fungicide use as an implicit function of the quality standard for disease by inverting the first equation (the equation relating fungicide use to disease damage). I then differentiated this implicit function to derive the change in fungicide use due to a change in the disease standard. For the uniform-quality case, I modeled the shifter measuring changes in the quality standard as changes in the weight placed on disease damage in the second equation (the equation relating damage to the percentage qualifying as low-quality), and used that relationship to calculate the change in fungicide use due to a change in the disease standard.

Comparison of the elasticities of fungicide demand with respect to a change in grading standards in the baseline scenario in both the mixed-quality and uniform-quality cases suggests the following. First, a stricter grading standard leads to more fungicide use in both cases under the baseline price assumptions. Second, fungicide use is more responsive to changes in the grading standard in the mixed-quality case than the uniform-quality case. Third, stricter grading standards can lead to decreases in fungicide use under conditions not too different from those in the baseline; specifically, as the elasticity of supply rises or the price differential between high- and low-quality fruit increase, the responsiveness of fungicide use falls. For example, an increase in the stringency of the grading standard reduces fungicide use at average usage levels when the elasticity of supply is 0.65 or greater, not too much larger than the baseline of 0.4.

Conclusion

These results suggest that the argument made in the environmental community about appearance standards resulting in greater pesticide use is only holds unambiguously in the restricted set of circumstances that van den Bosch (1975) and Pimentel et al. (1977) first discussed, namely mixed-quality sales, such as occur with FDA standards for residues or insect parts). That argument cannot be generalized to the case where fruits and vegetables are sold in lots of uniform quality, as typically occurs, because in this case, grading standards may induce growers to reduce pesticide use under highly plausible conditions. Thus, broad assertions about linkages between grading standards and pesticide use are not justified.

Endnotes

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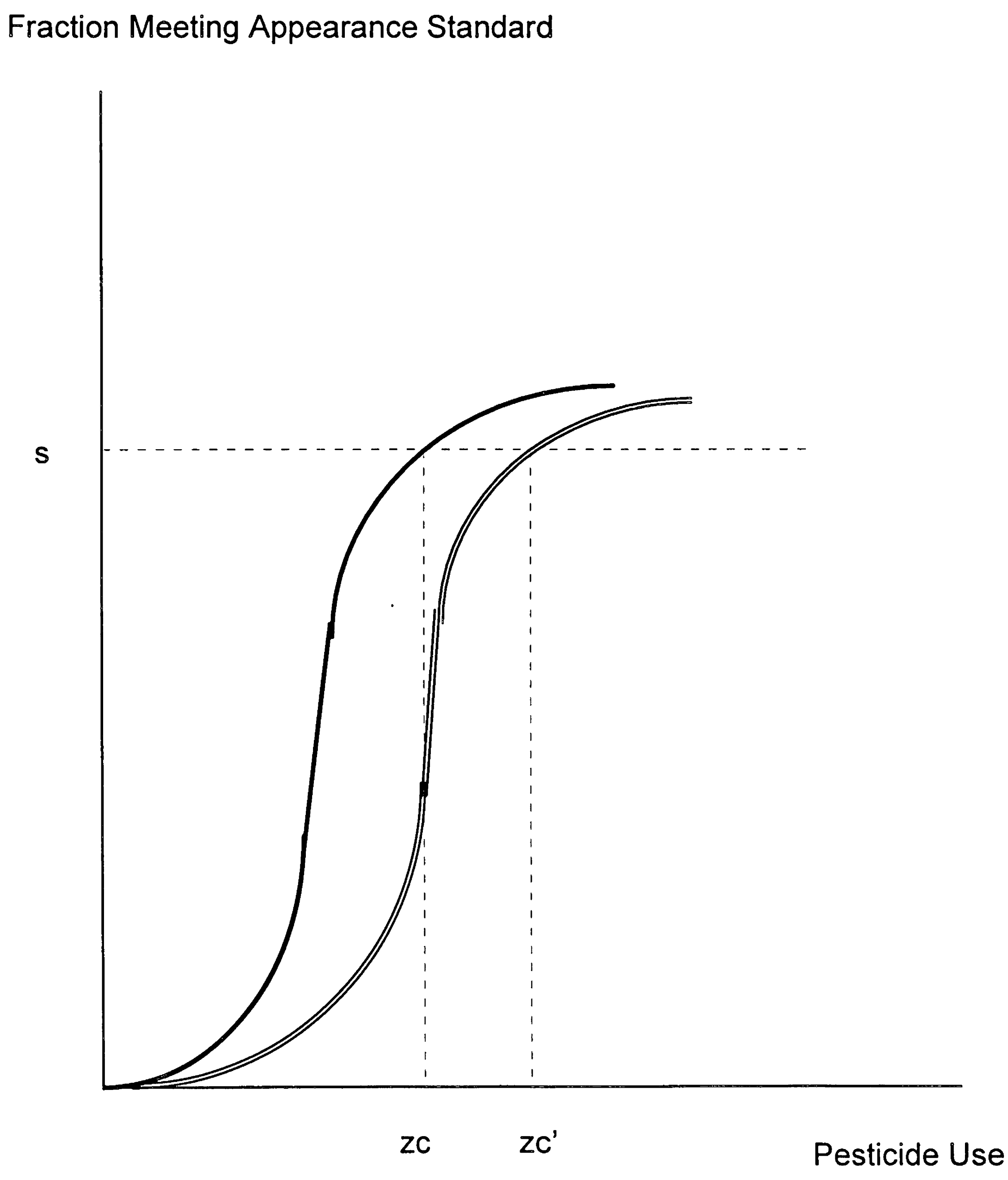
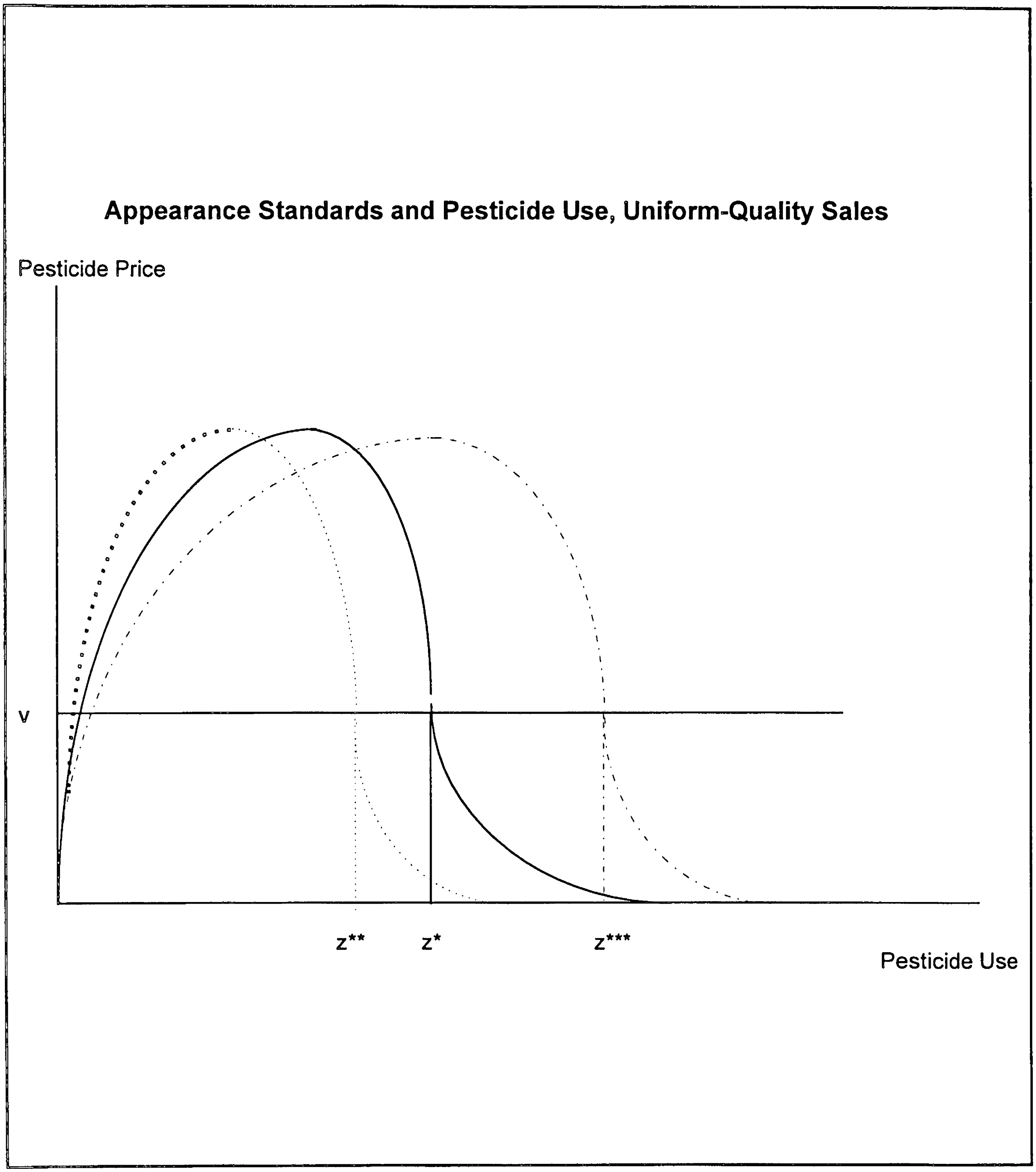
Appearance Standards and Pesticide Use, Mixed-Quality Sales

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