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CONSUMER WILLINGNESS TO PAY TO AVOID PESTICIDE RESIDUES

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Abstract: The economic value consumers place on reductions in health risks is examined in the context of the choice between conventionally and organically grown fruits and vegetables, where the latter are cultivated without the use of synthetic pesticides. Price differences between organic and conventional versions of 27 produce types are estimated using retail price data. These differences provide a lower bound on the incremental value that consumers who purchase organic produce assign to it. The risk avoided by substituting organic for conventional produce is evaluated to compare the cost-effectiveness of risk reduction across produce types and relative to risk-saving behavior in other contexts.

Key words and phrases: Health risk, willingness to pay, value of life.

1. Introduction

As highlighted by the recent controversy over Alar use on apples, consumers are concerned about widespread use of pesticides and other synthetic chemicals on food crops. In the United States, 69 percent of fruit acreage is treated with insecticides, including 91 percent of apple and 72 percent of citrus acreage (Pimentel et al. (1978)). Three-quarters of the public considers the use of pesticides and other chemicals a serious hazard (Food Marketing Institute (1986)). Some are sufficiently concerned that they substitute "organically grown" for conventional produce, even though organic produce is frequently more expensive and less widely available. Although it constitutes only a small fraction of the fresh produce market, availability and sales of organic produce are increasing (Franco (1989), Hall et al. (1989)).

This study describes consumer willingness to pay (WTP) for reductions in pesticide residues using estimated price differences between organic and conventional versions of 27 types of fresh produce, and compares the value consumers implicitly assign to reducing pesticide-related health risks to values of health-risk reduction estimated in other contexts. The principal assumption underlying this revealed-preference approach is that consumers choose from among a set of available commodities by optimally trading one valued attribute (smaller health risk) for another (lower price) (Lancaster (1966)). Other studies have estimated WTP for food safety using temporal demand shifts for individual products associated with changes in consumer information, e.g., Alar and apples (van Ravenswaay and Hoehn (1991a)), heptachlor and milk (Foster and Just (1989)), EDB and baked-goods mixes (Johnson (1988)), kepone and oysters (Swartz and Strand (1981)), and mercury and pheasant hunting (Shulstad and Stoevener (1978)).

Consumer choice between organic and conventional produce is modeled in Section 2 and premiums for organic versions of selected produce types are estimated in Section 3. Consumers who purchase organic produce reveal that their WTP is at least as great as the market premium. Estimating the size of this premium is relatively straightforward, because the prices of organic and conventional produce are observable. Understanding what consumers who pay the premium are buying is more difficult, however. The magnitudes of cancer and other health risks associated with chronic consumption of low-level pesticide residues are highly uncertain and there is a possibility that consumption of organic produce creates offsetting risks, e.g. if strains with higher levels of natural toxins are used (Ames (1983), Ames et al. (1987)). Consumers may also choose organic produce because they perceive the risk reduction to be much larger than toxicologists estimate or because they value other attributes, such as differences in taste, appearance, or the self-image associated with choosing organic produce.

Two aspects of the risk reduction being purchased are examined. In Section 4, differences across food types in the cost-effectiveness of risk reduction are examined, using several "risk indices" as proxy measures of relative risk. In Section 5, the absolute risk reduction associated with substituting organic for conventional produce is estimated in order to assess the monetary value of risk reduction implicit in organic-produce consumers' behavior and to compare it with values estimated from behavior in labor market and other contexts.

2. Consumer Choice and Willingness To Pay

Assume the representative consumer seeks to maximize utility

$$U = U(q, x, z) \tag{1}$$

where q is the quantity of a particular type of fresh produce consumed (say, carrots), $x = 1$ if the consumer purchases the organic version and 0 otherwise, and z is a composite of all other goods. The consumer faces the budget constraint

$$(\pi + px)q + wz \leq M \tag{2}$$

where π is the price of the conventional produce, p is the organic premium (the price difference between organic and conventional versions), w is the price of the composite good z, and M is income. If carrots are purchased ($q > 0$), the consumer will choose the organic version only if the incremental utility exceeds the difference in cost,

$$U(q^*, 1, z^*) - U(q^*, 0, z^*) > \lambda p q^* \tag{3}$$

where λ is the marginal utility of income (the Lagrange multiplier on the budget constraint) and the optimal quantity q^* is assumed to be independent of the choice between organic and conventional carrots.[1]

The utility difference may be decomposed as

$$U(q^*, 1, z^*) - U(q^*, 0, z^*) = R(q^*) + T(q^*) \tag{4}$$

where $R(q)$ is the consumer's perceived incremental health benefit of consuming q units of organic rather than conventional carrots and $T(q)$ summarizes the preferences for differences on other attributes including taste, appearance, and self-image. Combining (3) and (4), the consumer will purchase organic carrots only if

$$\lambda q^* p < R(q^*) + T(q^*) \tag{5}$$

or

$$p < \frac{1}{\lambda}\left[\frac{R(q^*)}{q^*} + \frac{T(q^*)}{q^*}\right] = \frac{b}{\lambda} \tag{6}$$

where b is the benefit of substituting organic for conventional versions of a produce type. Van Ravenswaay and Hoehn (1991b) provide a similar derivation of WTP based on Lancaster's (1966) hedonic model.

The relative importance of health benefits, $R(q)$, and non-health benefits, $T(q)$, is uncertain. In focus-group interviews, Hammitt (1990) found that health risks were reported to be the most important factor for consumer choice, but consumers are uncertain about their magnitude because they have limited information about pesticide concentrations, the cumulative toxicity of repeated exposure to trace quantities, and the extent to which pesticides may be removed by washing, cooking, and other treatment. Subjects reported little or no difference in taste but recognized that appearance varies because organic produce is usually not waxed and is less consistent in size and color. Similarly, Schutz and Lorenz (1976) found little taste difference between paired samples of broccoli, carrots, green beans, and lettuce grown under conventional and organic conditions. In a blind test, their subjects reported no significant taste differences except that conventionally grown carrots were preferred to the organic version. When produce types were labelled (correctly or incorrectly), tasters often preferred whichever product was labelled organic, suggesting the importance of other factors.

3. Organic-Premium Estimates

Premiums are estimated using retail prices of organic and conventional produce. Because quantities are not available, it is not possible to attribute the premiums to differences in supply or demand conditions. Regardless of the extent to which premiums are supply- or demand-driven, however, some consumers purchase the organic versions and so reveal a WTP for organic produce at least as large as the market premium.

Retail prices for organic and conventional versions of 36 produce types, matched by variety, were obtained from two food cooperatives and one health-food supermarket in the Los Angeles area. These stores offer both organically and conventionally grown produce, although availability varies by week. The cooperatives are open to nonmembers and all three stores are sufficiently well stocked that a consumer could purchase all the groceries at any one. Prices were observed at 10 weekly intervals beginning in May 1985; because prices and availability vary seasonally, the results pertain to the late spring/early summer period.

Premiums are estimated independently by food type using two methods, "regression" and "differential". Using the regression method, prices of organic and conventional versions of each produce type are modeled as

$$y = \pi + px + \sum_j \beta_j m_j + \sum_k (\gamma_k + \alpha_k x) w_k + \delta s + \varepsilon \tag{7}$$

where

y = price at store j and week t;

x = indicator variable equal to 1 if organically grown, 0 otherwise;

m_j = indicator variable equal to 1 if store j, 0 otherwise, $j = 2, 3$ (store 1 is omitted category);

w_k = (week t)^k (centered), $k = 1, 2, 3$;

s = size of individual items (+1 if labeled large, −1 if labled small, 0 otherwise);

ε = i.i.d. random error with mean 0; and

$\pi, p, \beta_j, \gamma_k, \alpha_k$ and δ are coefficients to be estimated.

To avoid confounding premium and store effects, produce types are analyzed by this method only if organic and conventional prices from the same store, or both organic and conventional prices from more than one store, were obtained, leaving 27 produce types. The number of observations for each type ranges from 21 to the maximum possible, 60.

Store, time, and size variables are included to further limit confounding premiums with other factors. Store effects may reflect differences in location, product selection, and convenience to consumers. Although one might expect store effects to be consistent across foods, the estimates are variable and quantitatively modest. Deleting these variables does not substantially affect premium estimates.

Temporal variation is controlled by fitting a polynomial function of time to the price and premium trends. Terms up to cubic were estimated; the selected models include the highest order terms that are statistically significant at the 5 percent level and all lower order terms. Of the 27 produce types, 10 regression equations contain no time variables, nine equations contain only a single linear term (the trend or interaction with premium), and six equations contain two linear (the trend and interaction) or a linear and a quadratic trend term. Premium estimates are not sensitive to the particular specification chosen, except for green peppers for which the organic version was available only toward the end of the period.

Item size s (as advertised at the produce bin) is the only variable to control for quality differences between organic and conventional produce. It was available intermittently for seven food types and has modest effects on the estimated premiums.

Premium estimates using the regression method are potentially sensitive to dependence among the errors. In particular, the store and time regressors may fail to remove any correlation between prices of organic and conventional versions of a food type at the same store and week. The "differential" method avoids this problem by estimating the premium from the difference between prices of organic and conventional versions of a produce type in the same store and week. The mean premium is then estimated using a regression model

$$\Delta = p + \sum_j \beta_j m_j + \sum_k \gamma_k w_k + \varepsilon \tag{8}$$

where Δ is the price difference (organic less conventional) for a produce type at a particular store and week and the other variables are defined as in Eqn. (7). This method can be used only when both versions of a produce type were available at the same store and week. Discarding cases with fewer than five such occurrences leaves 13 food types for which premiums can be estimated. In four cases each, the highest order time variable is constant, linear, and quadratic. Because the time variables are centered, the point estimate for the premium is not affected but the standard error is.

Premium estimates using each method are reported in Table 1. In cases where they are available, premiums estimated using the differential method are generally consistent with those estimated by the regression method; in only one case do the estimates differ by more than two (regression-method) standard errors.

For most produce types, the estimated premium is substantial relative to the mean price of the conventional version. In all but nine cases, the estimated premium is more than twice its standard error. For a few produce types (lemon, avocados, grapefruit, cauliflower), the estimated premium is less than zero, but never significantly so. The median ratio of the estimated organic premium to the mean price of the conventional version is 36 percent; the quartiles are 84 and 6 percent.

These premium estimates are comparable to estimates of WTP to avoid Alar contamination of apples. Using sales data for the New York metropolitan region, Van Ravenswaay and Hoehn (1991a) estimated a WTP for uncontaminated apples rising from 12 to 31 percent of the base price as the Alar controversy developed over the period 1984–1989.

4. Risk Indices

Evaluating the relationship between avoided risk and premium across produce types requires a measure of the relative risk imposed by residual pesticides. The limited available data on pesticide toxicity and concentrations (National Research Council (1984, 1987)) do not justify a comprehensive risk analysis. As an alternative, simple *risk indices* are used as proxy measures of $R(q)$, the average reduction in the probability of illness or premature mortality resulting from substituting the organic for the conventional version of a specific produce type. Alternative indices are used to evaluate the sensitivity of comparisons across produce types to differing estimates of avoided risk.

The risk indices assume risk is linear in produce quantity

$$R(q) = rq \tag{9}$$

and approximate the coefficient r by

$$r = \sum_j \theta_j c_j \omega_j \tag{10}$$

where the summation is over all pesticides found on a food type, θ_j is the probability that the jth pesticide contaminates an individual serving, c_j is the expected concentration of the jth pesticide, conditional on contamination (in parts per million, ppm), and ω_j is a weight chosen in accordance with some indicator of the relative toxicity of the jth pesticide, described below.

The exposure measures θ_j and c_j are estimated from samples tested by the California Department of Food and Agriculture (CDFA) in 1984. CDFA tested more than 100 samples of each produce type (taken from retail and wholesale markets and distribution centers) using multiresidue procedures that permit detection of more than 100 pesticides at concentrations below their legal tolerances. Unpublished CDFA summaries show that 34 pesticides were identified on one or more food types, but no residues were detected on about 90 percent of samples. Because comparable information for organic produce is not available, pesticide levels are assumed to be negligible[2] as are possible offsetting risks from organic produce.

Values of five alternative risk indices for each food are reported in Table 2, together with estimated organic premiums. The *Frequency* index is the simplest, defined as the expected number of pesticides found on a sample of a food type ($c_j = \omega_j = 1$). It departs from Eqn. (10) in that the concentrations c_j are replaced with dichotomous variables indicating presence of the jth pesticide at any detectable level. This index neglects the magnitude of concentrations but emphasizes exposure to multiple pesticides which may be synergistic.

The *Concentration* index emphasizes quantity without differentiating among pesticides of differing toxicity. It is defined as the sum of expected concentrations ($\omega_j = 1$) and so treats all pesticides as equally toxic.

The *Tolerance* index uses the legally permitted residual concentration (40 CFR 180) as a measure of relative hazard ($\omega_j = 1/\text{tolerance}_j$). It would measure aggregate toxicity if regulators set tolerances to equalize the risk from each pesticide (i.e., inversely proportional to toxicity), but tolerances are based on other factors as well, including the normal residue given proper use on a crop and the crop's contribution to a typical diet. Moreover, because tolerances are food-specific, the absence of a tolerance for a pesticide/food combination may reflect not the hazard but only the producer's reluctance to incur registration costs when the expected market is small. (In the few cases where CDFA tests found pesticides on foods for which there is no tolerance, a tolerance of 0.05 ppm, one-half the smallest tolerance usually found, is assumed in calculating this index.)

The *Acute* index uses the reciprocal of the LD_{50}, the dose estimated to be lethal in one-half the animals on test (measured in mg per kg animal body weight), as a measure of toxicity.[3] Residues are weighted by the percentage of the LD_{50} so the range of values is similar to those of the other indices ($\omega_j = 100/\text{LD}_{50j}$).

The *Chronic* index uses information on chronic health effects reported by the National Institute for Occupational Safety and Health (1984). The weights ω_j are based on the most serious of four tumorigenic effects identified there and are intended to reflect the relative expected carcinogenic potency, i.e., carcinogen (1), neoplastigen (1/2), equivocal tumor promoter (1/4), mutagen (1/8). The weight is increased one unit if the pesticide is also an identified teratogen. This index is similar to one used by Pederson and Hornung (1986) to rank worker exposures by industry.

Although the risk indices employ disparate proxies for toxicity, they produce similar rankings of pesticide risks across food types (Table 3). The weakest correlations are between the rankings based on the Acute and the Chronic and Concentration indices, but even these have correlation coefficients greater than 0.7. All of the correlations between risk indices are highly significant. In contrast, there is no significant correlation between the organic premium and any of the risk indices (Table 3 and unreported graphical analysis). The absence of correlation is consistent with the hypothesis that premiums are determined largely by differences in supply costs and that demand for reduced pesticide risks is primarily reflected in market quantities. The price of the conventional version of each food type is not significantly correlated with either the organic premium or any of the risk indices.

Using the risk indices as proxies for the incremental risk coefficient r (Eqn. 9), produce types can be ordered by the estimated ratio of the premium p to the benefit b (Eqn. 6) and WTP per unit risk avoided can be inferred. The ranking is presented in Table 4. In making these comparisons, preferences over non-risk factors cannot be quantified and are assumed negligible, $T(q) = 0$, so the benefit is equal to the avoided risk, $b = R(q)/q$. If $T(q)$ is generally positive for consumers who purchase organic produce, inferred WTP may overestimate the extent to which these consumers value health. In addition, although a consumer who purchases organic produce implicitly reveals that the WTP exceeds the premium/avoided-risk ratio p/b for that produce type, because consumers have only limited information about incremental risk differences across produce types (Hammitt (1990)) it may be useful to use some average estimate of WTP per unit avoided-risk rather than produce-type-specific measures.

Taking the ratio of premium to Concentration index as an example, a consumer who usually buys organic produce might be inferred to value an average one ppm reduction in pesticide residues at least 39 cents per lb. of produce (the median across produce types in Table 4) or perhaps \$2.75 per lb. (the upper quartile). A consumer who never purchases organic produce might be inferred to value the same reduction by less than 39 cents per lb., or perhaps less than 3 cents per lb. (the lower quartile). Ratios using the other risk indices can be interpreted similarly; i.e., as WTP in dollars per pound of produce for an average reduction of: one detectable pesticide (Frequency), 100 percent of the legal tolerance for a pesticide (Tolerance), one percent of the LD_{50} for a pesticide (Acute), and one ppm of a carcinogenic pesticide (or a greater quantity of potential carcinogens) (Chronic).

The ranking of produce types provides information about the relative cost-effectiveness of risk reduction by food type. Even though the risk indices are highly correlated across produce types, the ranking is somewhat sensitive to the index used. Among the 20 food types with non-zero risk indices and positive estimated premiums, all but one rank among the eight least cost-effective (highest premium/risk-index ratios), and seven rank among the three most cost-effective (lowest premium/risk-index ratios), under at least one of the indices. The three food types with estimated premiums less than zero are most cost-effective under any index.

5. Willingness To Pay To Reduce Mortality Risk

To compare WTP for reduced mortality risk with estimates based on other risk-saving behaviors (Fisher et al. (1989)), the risk avoided by reducing pesticide consumption must be estimated. Because uncertainty about pesticide exposures and hazards compound to produce substantial uncertainty about risk, the following estimates should be interpreted cautiously.

As the quantitities of pesticide residues are small, the primary mortality risk may be due to cancer. The representative consumer's reduction in lifetime cancer-mortality risk if residual pesticides are avoided, Γ, can be estimated as

$$\Gamma = f \rho c F / W \tag{11}$$

where f is the mass-weighted fraction of residues that are carcinogenic, ρ is their mass-weighted average carcinogenic potency, c is the average residue concentration in produce, F is the consumer's average daily produce consumption, and W is the consumer's weight. Values of f and ρ can be estimated using the TD_{50}, the dose (per unit body weight) at which half the animals on test develop tumors (Peto et al. (1984)). The carcinogenic potency can be estimated using the one-hit model (which approximates the standard linearized multistage model) by

$$\rho' = [\log(2)\mathrm{TD}_{50}]^{-1}. \tag{12}$$

Gold et al. (1984) report TD_{50}s for half the pesticides in the CDFA incidence data (Hammitt (1986)); let $f = 0.5$ and $\rho = 0.3$ (mg/kg-day)$^{-1}$, the mean of ρ' for these pesticides. Let $c = 0.25$ ppm, the median of the Concentration risk index, and let F and W equal 0.25 kg/day and 60 kg respectively. With these assumptions, $\Gamma \approx 1.6 \times 10^{-4}$.

Because Γ is a reduction in lifetime risk, WTP must be converted to a lifetime measure. Assume the representative consumer decides at some age to purchase organic produce for the remaining lifetime. The present value of the associated premiums is the product of the average premium, average annual produce consumption, and a factor

$$D = \sum_{t=0}^{T} (1+d)^{-t} \tag{13}$$

where d is the discount rate and T is remaining life expectancy. Using the median premium of \$0.23/lb., 0.25 kg/day produce consumption (F in Eqn. 11), $d = 5$ percent/year and $T = 50$ years, the present value of the increased expenditure is about \$890. The implicit "value of life" (the value of a marginal risk reduction scaled, by convention, to unit risk) is this incremental expenditure divided by the avoided risk or about \$5.5 million, consistent with the range of \$1.6 million to \$8.5 million estimated from studies of labor markets, seatbelt use, and smoke-detector purchase (1986 dollars; Fisher et al. (1989)).

These results are broadly consistent with other food-risk studies. Van Ravenswaay and Hoehn (1991a) estimate a value of life ranging from about \$1.6 million to \$30 million (1986 dollars) using market reactions to Alar contamination in apples. The 18-fold range is composed of a factor of 6.8 due to the choice between risk estimates and a factor of 2.7 due to the change in WTP over time. Using contingent valuation studies, respondents have been asked to report both their WTP and their estimate of the avoided risk. In a pilot study, Hammitt (1990) found median values of life of \$0.75 million and \$6.6 million for consumers who frequently and never purchase organic produce, respectively. The organic-produce consumers reported higher WTP than the conventional-produce consumers (median 50 percent and 5 percent of the conventional price, respectively) but much higher avoided risk (median 8×10^{-4} and 5×10^{-7} excess lifetime mortality risk). Van Ravenswaay and Hoehn (1991b) estimated values of life of about \$0.6 million and \$2.2 million (1990 dollars) in a study of WTP for pesticide labelling on apples, the difference reflecting alternate assumptions needed for their risk estimate.

6. Conclusions

Organically grown produce oftens sells at a premium relative to conventional produce. Of the 27 produce types evaluated, estimated organic premiums are positive for 23 and the median ratio of the organic premium to the conventional price across produce types is about one-third. Whether consumers who purchase organic produce are getting their money's worth in risk saving is difficult to determine. Premiums are uncorrelated with several proxy measures of risk reduction, suggesting that they are determined by differences in supply costs between organic and conventional produce but not by differences in demand. The price of risk reduction appears consistent with the values estimated in other contexts, which suggests that organic-food consumers are not overpaying for risk reductions although uncertainties in estimating risk preclude a definitive judgment.

Notes

[1] The effect of produce version on the optimal quantity of z (because of the small difference in residual income) is ignored.

[2] California requires that produce sold as organically grown must display a label stating that it was grown in accordance with the applicable law which prohibits application of synthetic pesticides and other compounds to the crop or field. Some produce is also certified by private organizations such as the California Certified Organic Farmers (private communication, Warren Webber, CCOF president). Environmentally persistent contaminants may be unavoidably present on organic as well as conventional produce, however.

[3] Values (for oral administration in rats) were obtained from the *Farm Chemicals Handbook '85* and Food and Drug Administration (1981).

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Table 1. Estimated organic premiums and conventional price

	Regression			Differential				
Food item	Premium	Std err	N	Premium	Std err	N	Conv. price	Prem/ price
Tomato	113.0	8.3	54	108.4	10.3	18	60.0	1.88
Bing cherry	99.2	17.2	37	127.5	15.3	8	182.7	0.54
Broccoli	70.0	7.2	40	83.4	1.7	10	57.2	1.22
Peach	65.9	8.5	38	61.3	12.6	9	80.3	0.82
Green pepper	41.5	9.4	28				79.9	0.52
Spanish onion	38.8	1.2	38	39.0	0	9	30.1	1.29
Zucchini	37.5	6.0	39	46.2	5.8	10	45.8	0.82
Cucumber	37.2	8.5	40	43.4	4.4	10	44.1	0.84
Green cabbage	34.3	3.5	29				28.6	1.20
Apple	33.9	4.7	39	52.5*	1.2	10	78.8	0.43
Celery	26.5	4.4	32	24.4	6.8	5	45.2	0.59
Red cabbage	26.5	5.0	29				30.1	0.88
Carrot	24.8	1.2	39	24.5	0.5	10	25.7	0.96
Yellow squash	23.5	13.9	21				80	0.29
Apricot	21.3	4.3	28				83.9	0.25
Spinach	17.2	2.7	34	19.2	0.2	6	64	0.27
Banana	12.3	2.1	50	14.5	1.2	21	33.8	0.36
Romaine lettuce	6.7	2.4	30				48.3	0.14
Leaf lettuce	5.8	2.0	60				47.5	0.12
Potato	3.4	1.8	40	0	0	10	39.9	0.09
Kiwi	2.5	3.9	30				44.6	0.06
Valencia orange	2.1	5.9	31				41	0.05
Red onion	0.7	2.6	29				49.1	0.01
Lemon	−5.6	5.3	30				67	−0.08
Avocado	−7.1	11.6	29				62.6	−0.11
Grapefruit	−8.2	4.8	40				46.6	−0.18
Cauliflower	−14.6	14.7	25				85.4	−0.17

Note: * Estimate differs from regression estimate of premium by more than two regression-estimate standard errors.

Table 2. Premiums and risk indices

		Risk index				
Food type	Premium	Frequency	Concentration	Tolerance	Acute	Chronic
Tomato	113.0	0.274	0.061	0.043	0.031	0.022
Bing cherry	99.2	0.209	0.417	0.021	0.010	0.104
Broccoli	70.0	0.290	0.255	0.054	0.158	0.369
Peach	65.9	1.379	1.985	0.373	0.285	0.983
Green pepper	41.5	0.513	0.325	0.182	0.919	0.330
Spanish onion	38.8	0	0	0	0	0
Zucchini	37.5	0.158	0.011	0.026	0.015	0.013
Cucumber	37.2	0.964	2.157	42.463	6.761	3.743
Green cabbage	34.3	0.289	0.239	0.060	0.755	0.103
Apple	33.9	0.045	0.048	0.007	0.039	0.003
Celery	26.5	0.571	0.681	0.071	0.372	0.286
Red cabbage	26.5	0.289	0.239	0.060	0.755	0.103
Carrot	24.8	0.174	0.063	0.082	0.122	0.058
Yellow squash	23.5	0.072	0.011	0.022	0.011	0.004
Apricot	21.3	0.175	0.350	0.035	0.052	0.612
Spinach	17.2	1.161	1.063	3.029	3.878	0.263
Banana	12.3	0	0	0	0	0
Romaine lettuce	6.7	0.340	0.267	0.068	0.529	0.125
Leaf lettuce	5.8	1.147	1.447	0.256	4.444	1.000
Potato	3.4	0.598	1.924	0.126	0.077	2.402
Kiwi	2.5	0.378	0.720	0.048	0.239	0.498
Valencia orange	2.1	1.369	3.016	0.273	0.454	3.873
Red onion	0.7	0	0	0	0	0
Lemon	−5.6	0.194	0.054	0.025	0.169	0.035
Avocado	−7.1	0	0	0	0	0
Grapefruit	−8.2	0.824	1.359	0.193	0.394	1.275
Cauliflower	−14.6	0.067	0.028	0.030	0.007	0.007
Upper quartile	37.5	0.598	1.063	0.182	0.529	0.612
Median	23.5	0.289	0.255	0.054	0.158	0.104
Lower quartile	2.5	0.072	0.028	0.022	0.011	0.007

Note: Premium in cents/lb. Risk indices defined in text.

Table 3. Spearman rank correlation coefficients across food types

	Premium	Frequency	Concentration	Tolerance	Acute	Chronic	Conv. price
Premium	1.0						
Frequency	0.07	1.0					
Concentration	0.03	0.94*	1.0				
Tolerance	0.05	0.93*	0.87*	1.0			
Acute	0.07	0.84*	0.74*	0.87*	1.0		
Chronic	0.00	0.90*	0.96*	0.85*	0.73*	1.0	
Conv. price	0.04	−0.07	−0.03	−0.17	−0.20	−0.07	1.0

Note: * Significantly different from zero at 1%.

Table 4. Premium/risk-index ratios

Food type	Frequency	Concentration	Tolerance	Acute	Chronic
Tomato	4.12	18.52	26.28	36.45	51.36
Bing cherry	4.75	2.38	47.24	99.20	9.54
Broccoli	2.41	2.75	12.96	4.43	1.90
Peach	0.48	0.33	1.77	2.31	0.67
Green pepper	0.81	1.28	2.28	0.45	1.26
Zucchini	2.37	34.09	14.42	25.00	28.85
Cucumber	0.39	0.17	0.01	0.06	0.10
Green cabbage	1.19	1.44	5.72	0.45	3.33
Apple	7.53	7.06	48.43	8.69	113.00
Celery	0.46	0.39	3.73	0.71	0.93
Red cabbage	0.92	1.11	4.42	0.35	2.57
Carrot	1.43	3.94	3.02	2.03	4.28
Yellow squash	3.26	21.36	10.68	21.36	58.75
Apricot	1.22	0.61	6.09	4.10	0.35
Spinach	0.15	0.16	0.06	0.04	0.65
Romaine lettuce	0.20	0.25	0.98	0.13	0.54
Leaf lettuce	0.05	0.04	0.23	0.01	0.06
Potato	0.06	0.02	0.27	0.44	0.01
Kiwi	0.07	0.03	0.52	0.10	0.05
Valencia orange	0.02	0.01	0.08	0.05	0.01
Lemon	−0.29	−1.04	−2.24	−0.33	−1.60
Grapefruit	−0.10	−0.06	−0.42	−0.21	−0.06
Cauliflower	−2.18	−5.21	−4.87	−20.86	−20.86
Upper quartile	2.37	2.75	10.68	4.43	4.28
Median	0.48	0.39	2.28	0.45	0.67
Lower quartile	0.06	0.03	0.08	0.05	0.05

Notes: Units are $/lb. produce per unit risk index. Four food types with risk-index values of zero are deleted.

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