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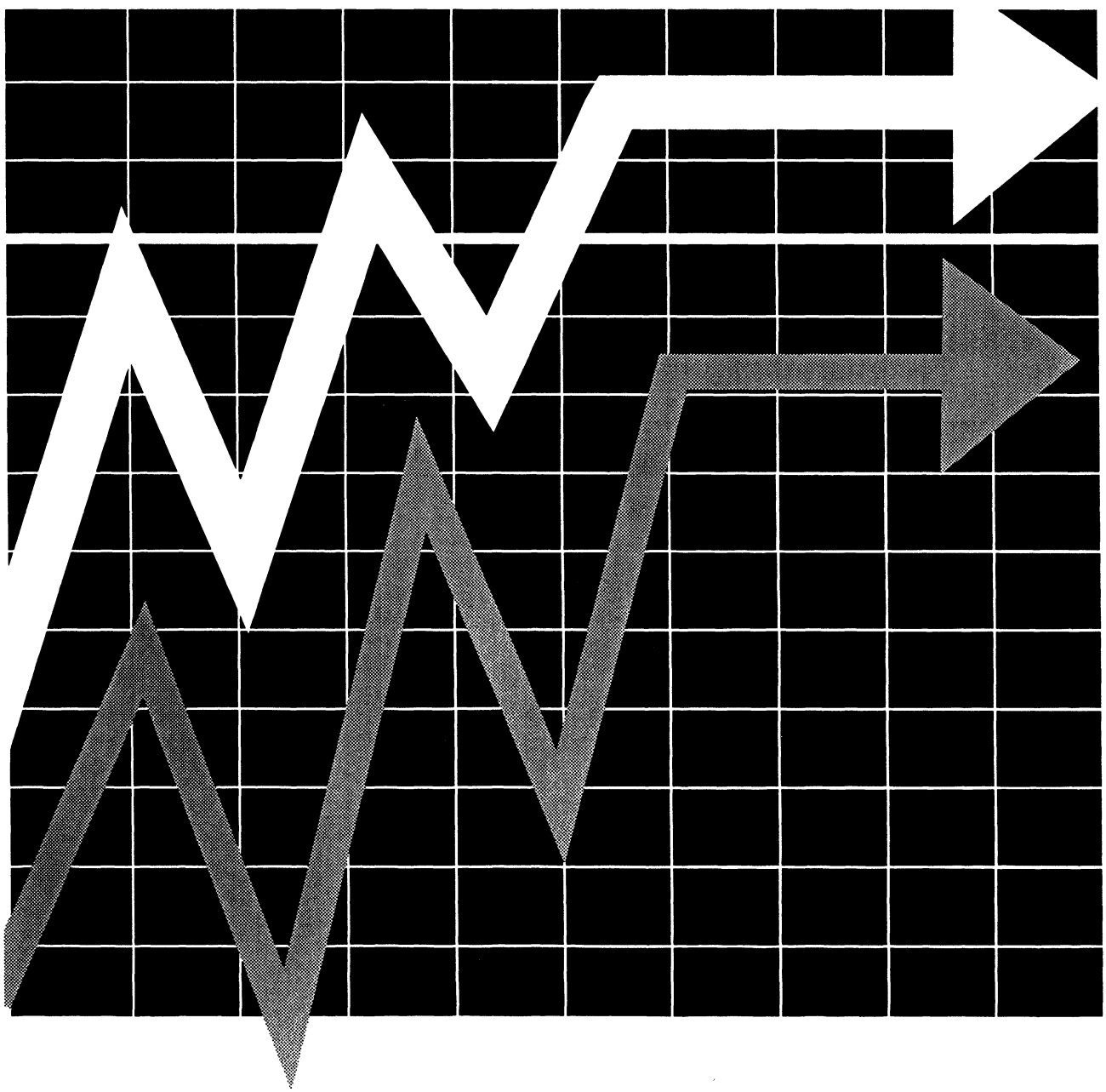
# Using Historical Information To Identify Consumer Concerns About Food Safety

Steven Payson





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## Abstract

The coverage of food safety issues by the news media could affect consumption patterns, depending on the type of food consumed and the type of risk involved. Media coverage of food safety concerns during 1937-91 was examined as an indicator of risk perception, based on information appearing in *Consumer Reports*. There was an increase in the coverage of food safety issues and a shift in media emphasis from acute food safety problems to chronic health problems. Consumption of beef, pork, poultry, and seafood for 1937-91 was examined as a function of real income, relative prices, time, and risk information. For beef, the impact of media coverage increased over time. For seafood, media coverage became relatively less important over time. These effects were not observed for poultry or pork products.

**Keywords:** Food safety, risk, news media, consumer behavior, beef, seafood, poultry, pork, substitution effects, historical information, *Consumer Reports*, historical trends, evolutionary trends, generalized least squares

## Acknowledgments

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# Contents

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Steven Payson*

## Introduction

Food safety in the United States is maintained through a variety of checks and balances, and one of the most important of these is the news media. When new regulations on food safety are needed, or when existing regulations require greater enforcement, the news media often create the impetus for change. This report focuses on how media information could have influenced consumer attitudes about food safety, thereby affecting trends in consumption patterns during 1937-91. Most studies of consumption patterns do not use a time span of more than 50 years. An advantage in using longer time spans is that it renders results that depend less on the particular circumstances of brief time periods. In this sense, a wide time span may capture those qualities of consumer behavior that are more closely related to longrun aspects of consumer psychology. Moreover, historical information on consumption and risk information may reveal evolutionary patterns in the risk information itself and in its effect on consumption.

Safety information is only one aspect of consumer tastes and preferences. Consumers also choose food according to their exposure to traditional and cultural approval of certain foods, their concern over the social and environmental issues associated with the products they purchase, and their attitudes toward various abstract ideas conveyed in labeling and advertising, like "natural" and "no artificial ingredients."

Recent research on the effect of safety information on consumption has been carried out on a variety of food items. Brown and Schrader found that the consumption of shell eggs in the U.S. had declined with increased medical news on the association between cholesterol and heart disease. Chang and Kinnucan obtained similar results for butter consumption in Canada using a comparable index of cholesterol information. Smith and others investigated the contamination of fluid milk with the pesticide heptachlor in Hawaii, and discovered a significant relationship between newspaper coverage of the issue and lost sales of milk. Van Ravenswaay and Hoehn observed a decline in the demand for apples in the New York City/ Newark metropolitan area in response to press releases on the health risks of Alar, a growth regulator used on apples.

This report examines all types of food safety information. However, in relating such information to consumption, the report focuses on beef, poultry, pork and seafood, and the tendency of consumers to adjust their consumption in response to new safety information about these products. The four products were chosen for several reasons. Together these products represent a substantial portion of consumers' expenditures on foods. They have all undergone considerable scrutiny by the news media with regard to safety. Furthermore, while these products do pose certain problems in the measurement of quantities and prices over time, such problems tend to be minor in comparison with those of other food products. Also, the products' quantity data correspond relatively well to price data.

The amount of news media attention paid to food safety over 1937-91 is enormous and certainly cannot be examined in its entirety. What is required, then, is a proxy of news media that could approximate the amount of attention given to each food safety issue. The proxy used in this study is the coverage of food safety in the journal *Consumer Reports*. *Consumer Reports* was chosen because it has long been an important source of consumer information and has had considerable influence on the coverage of consumer issues by other news media. In addition, *Consumer Reports* has existed throughout the time span consid-

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ered, thereby allowing for a historical analysis. *Consumer Reports* has already been used successfully by economists in the study of historical trends (Gordon, 1990). The journal provides extensive information on the full spectrum of food safety issues, and is comparable to other media sources that have been used for similar purposes, like *The New York Times* (van Ravenswaay and Hoehn, 1991) or *Medline*, a database on articles related to health and safety (Brown and Schrader, 1990).

Finally, media coverage of food safety issues can be seen as doing more than providing information to consumers. It serves a different purpose — that of conveying information to policymakers, on behalf of consumers. In this respect, consumer concern over food safety, as reflected by their own individual actions and statements, may underestimate the true importance they place on food safety, because they have entrusted the news media, as well as the government, with the responsibility of evaluating food safety. Consequently, information on media coverage of food safety could be an important analytical supplement to the information on consumer attitudes toward food safety obtained through consumer surveys and observed market behavior.

## *Consumer Reports* and Food Safety Issues

The amount of media information provided on various food safety issues is a good indicator of the relative importance of those issues to the consumer. Television and radio have an opportunity cost in their use of air time to address food safety issues, while journals or newspapers have the same opportunity cost with regard to printing space. Similarly, consumers have opportunity costs of their own in the time they take to watch, hear, or read information about food safety. Hence, a marginal increase in the amount of information on a topic would tend to be proportional to the marginal benefit derived by consumers from that additional information, all else being equal.

The journal *Consumer Reports* is an important source of media information, although it may have limitations as a proxy for all media reporting on food safety. The journal, founded in May 1936, remains a monthly publication of Consumers Union. Consumers Union was originally concerned with whether products had the union label (produced in establishments with unionized labor). The organization has since evolved into the most prominent consumer watchdog in the United States, with *Consumer Reports* reaching 5 million households and establishments.[1] Its editors appear to make deliberate efforts to present information objectively, as reflected by their policy to have no advertising in the journal.

On the other hand, the historical coverage of food safety issues by *Consumer Reports* may not always represent the interests of consumers. It could be biased in favor of particular viewpoints held by the editors of the journal or by the people and institutions who subscribe to the journal. The journal tends to devote a great deal of attention to aspects of food safety that evoke strong emotions, such as fragments of insects found in food, even though these aspects may not be particularly harmful in terms of their actual health effects. This tendency of the journal to highlight certain aspects of food production that are not particularly hazardous is seen by some to compromise its objectivity toward food safety issues. In this sense the journal may reflect the attitudes of consumers, if consumers attach more importance to risks that are more apparent than real (Sandman, 1992).

The amount of coverage on each food type and food safety issue was quantified on the basis of the number of paragraphs appearing in *Consumer Reports*. To be counted, a paragraph had to contain over two full lines of text. In addition, every distinct table or graph was also counted as a single paragraph. While paragraphs did vary in length, few were exceptionally long, and there were no apparent trends in the length of paragraphs over time or across different products or food safety issues. If an entire article were devoted to a specific food safety issue, then all of the paragraphs in the article were counted under the same issue. However, paragraphs were examined and evaluated individually in most cases. A rule was established that a paragraph could be counted only once with regard to an issue and food type, and so, judgment calls were made in choosing a single issue and food type for paragraphs associated with more than one issue or food type.

This study introduces an additional concept, the detailed news story (DNS), in relating risk information to consumption. A DNS was defined as a collection or set of safety paragraphs referring to a particular product (such as beef) and a particular safety issue (such as contamination with unsafe microorganisms). A DNS spans more than 1 year and is considered to end when 2 consecutive years contain no safety paragraphs on the specific product and safety issue in question. An additional requirement was that a DNS

[1]The figure of 5 million was conveyed in a telephone conversation with a *Consumer Reports* representative on April 13, 1993.

must contain at least four safety paragraphs in total. Because information is not normally forgotten from December of one year to January of the next, a DNS was defined as extending to the first year in which safety paragraphs are absent. For example, if there is news coverage of microbial contamination of seafood appearing in every year from 1961 to 1975, but then not appearing thereafter, then this DNS would be said to exist (or exert its influence) from 1961 to 1976. The number of safety paragraphs per year for a DNS is the mean number of paragraphs across the entire time period.

This adjustment of the risk information data into DNS's served two purposes in the analysis of the effects of information on consumption: it eliminated the most sporadic occurrences of safety paragraphs that were not likely to coincide with media coverage of the same product and issue by other media sources and, conversely, gave greater weight to those paragraphs that would reflect coverage by other sources. Also, this adjustment tended to smooth out the data in a manner that might better reflect the development of consumer attitudes. For example, suppose a single product and issue were extensively covered in one year and then mentioned only briefly in the year that follows. In the latter year, the consumer is likely to draw upon his memory of the previous year's coverage, and thus the number of paragraphs that actually exists in the latter year might otherwise under-represent the importance of those paragraphs in evoking consumer response.

Table 1 categorizes food safety issues appearing in *Consumer Reports*. There are three main categories of issues: contamination, inherent aspects of the manufactured food product, and absence of accurate or up-to-date knowledge about health effects. These main categories are divided into second- and third-level subcategories, comprising a total of 22 individual issues.

Because each food safety paragraph was counted equally, an important limitation in the data is that the number of paragraphs on a particular food or food safety issue may not reflect the sense of urgency that consumers have toward the information provided. For example, a paragraph that warns against the possibility of acute fatality (such as from a canned food product contaminated with botulin) would invoke a much greater sense of risk than one that warns against a product that contains too much sugar. However, the breakdown of paragraphs by food safety issue can help account for this difference. For instance, whether

**Table 1--Categorization of food safety issues, by cause**

| I. Contamination | II. Inherent aspects of the manufactured food product | III. Absence of accurate or up-to-date knowledge about health effects |
|---|---|---|
| A. Chemical contamination<br>1. Pesticide residues<br>2. Fertilizer residues<br>3. Toxic waste residues<br>4. Animal hormones, antibiotics, etc.<br>5. Chemicals in processing operations<br>6. Foreign objects (such as pieces of glass) | A. Unsafe additives<br>1. Artificial colors and flavors<br>2. Preservatives<br>3. Fillers, emulsifiers, softeners, and other additives | A. Marketing<br>1. Misleading labeling<br>2. Deceptive advertising |
| B. Biological contamination<br>1. Unsafe microorganisms<br>2. Natural toxins<br>3. Infestations (such as trichinosis from pork)<br>4. Filth and improper cleaning | B. Unsafe for certain individuals<br>1. Allergies, sensitivities, and dietary ailments<br>2. Unsafe if consumed in excess (such as sugar, caffeine, cholesterol, and saturated fats) | B. Unsafe rumors, traditions, or practices<br>1. Biases toward or against various products<br>2. Unsafe household cooking or storing practices |
| C. Nuclear radiation<br>1. Radioactivity from nuclear fallout or leakage from nuclear facilities | | C. Unannounced reductions in nutritional value<br>1. Removal of nutrients in processing<br>2. Dilution of nutritional components per unit weight or per calorie content |

information on contamination has a greater effect on consumer behavior than other types of information could be tested. Furthermore, *Consumer Reports* does tend to contain more paragraphs on issues that are most important to consumer safety. Such importance depends not only on how ill a person could become, but on the number of people who would be affected.

## How Has Food Safety Information Changed?

Many food safety issues recur over time; however, a variety of food products or chemicals can fall under the same issue. For example, the issue of pesticide residues in food has appeared in *Consumer Reports* continually from 1938 to the present. The pesticides drawing attention included lead arsenate in 1938, DDT in 1949, aminotriazole in 1960, dieldrin in 1971, a set of chlorinated hydrocarbons found in milk in 1974; and Alar (daminozide) in 1986. Attention to pesticide residues also occurred in 1963 in response to the climate created by Rachel Carlson's *Silent Spring*, which had been published a year earlier.

Table 2 presents the number of paragraphs falling under the 22 food safety issues for each year during 1937-91, and figures 1 and 2 summarize these observations. Figure 1 displays the number of paragraphs falling under each of the three major categories by year, and figure 2 shows the total number of paragraphs falling under each of the 22 issues for 1937-91 and 1987-91.

Attention to food safety issues has increased over time (fig. 1). Issues involving "inherent aspects" of food products and "inadequate knowledge" about safety increased in relative importance beginning in 1977. Contamination, especially biological and chemical contamination, remained an important concern throughout the 55 years.

The issue "unsafe microorganisms" received the most attention in terms of the number of paragraphs during 1937-91 (fig. 2). It is followed in importance by "undesired substances when consumed in excess, such as sugar, salt, caffeine, cholesterol, and saturated fats." The third most important issue is "pesticide residues," though this is closely followed in importance by "artificial colors and flavors" and "misleading labeling." During 1987-91, "unsafe microorganisms" ranked third along with "deceptive advertising" and "chemicals in processing operations." In this 5-year period, "undesired substances when consumed in excess" received the most attention, closely followed by "pesticide residues."

The increased attention to food safety, including chronic health risks from excess consumption, probably reflects the increased value of that information to a population with higher income and longer life expectancy. The shift in the relative rankings of microorganisms and pesticide residues is also notable, and closely corresponds with other surveys of consumer concerns.[2] Although the list in figure 2 does not exactly match a ranking by hazard (such as the average reduction in life expectancy), it is close. Where it varies could reflect the influence of consumer outrage associated with particular observations about food, for example, the observance of rodent hairs in various products.

Finally, table 3 presents some examples of the specific concerns addressed in *Consumer Reports* articles on food safety over 1937-91. The year denoted in the table represents only one of the years in which the concern is addressed — in most cases the same concern is mentioned in several years. Food safety researchers might wish to relate historical information of this kind to the causal factors that underlie them. These causal factors would include specific historical events (such as the Alar scare), changes in household production practices (such as microwave cooking), agricultural and industrial innovations (such as new pesticides), public knowledge of food safety issues (such as concern over cholesterol intake), accumulation of scientific knowledge about food safety, living standards, trends in labeling and advertising, education and sociological factors (such as consumer knowledge about preventing spoilage), and the growth of sedentary labor and calorie consciousness.

## Effects of Media Coverage and Other Factors on the Consumption of Meat Products

Statistical tests were conducted to estimate the effects of prices, income, time (the year in which consumption takes place), and media coverage on the consumption (in pounds per capita) of beef, pork, poultry, and seafood. A detailed description of the economic model and statistical results underlying this analysis is presented in the appendix.

Of the 22 food safety issues identified in the last column of table 1, 16 were mentioned at least once by

[2]See van Ravenswaay, 1992.

## Table 2–Paragraphs in *Consumer Reports* on food safety issues, as categorized in table 1, by year, 1937-91

| | Contamination | | | | | | | | | | | Inherent aspects | | | | | Absence of knowledge | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Chemical | | | | | | Biological | | | | Nuc. | Additives | | | Indiv. | | Mktg. | | Rumor | | Red. | | |
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3 | 4 | 1 | 1 | 2 | 3 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | Total |
| | | | | | | | | | | | | *Number of paragraphs* | | | | | | | | | | | |
| 1937 | | | | | | | 7 | | 1 | 1 | | | | | | 1 | | | | | 2 | | 12 |
| 1938 | 40 | | 21 | | 17 | | 2 | 13 | 7 | 2 | | | | | 2 | | 27 | | | | 2 | | 133 |
| 1939 | | | | | | | 27 | | | | | | | | 2 | 29 | | 16 | | 21 | | | 95 |
| 1940 | 14 | | | | | | | | 71 | 2 | | 1 | | | 5 | 1 | 2 | 2 | 2 | | 1 | | 101 |
| 1941 | | | | | | 2 | 22 | | 4 | | | | | | | | 1 | | | | | | 29 |
| 1942 | | | | | | | 33 | | | 1 | | | | | | 9 | | | | | | | 43 |
| 1943 | | | | | | | | | | 1 | | | | | 1 | | | | | | | | 2 |
| 1944 | | | | | | | 40 | | 11 | | | | 1 | | | | | | | | | | 52 |
| 1945 | | | | | | | 3 | | 18 | | | | | | 1 | | | | 2 | | | | 24 |
| 1946 | | | | | | | 7 | | 2 | | | | | | | | | 5 | | | | | 14 |
| 1947 | | | | | | 3 | | | 5 | 7 | | | | | | 3 | | 16 | | | | | 34 |
| 1948 | | | | | | | 8 | | 5 | 7 | | | 25 | 1 | | | 3 | 6 | | | 4 | | 59 |
| 1949 | 30 | | | | | | 2 | | 5 | 1 | | 23 | 25 | | | | | 5 | | | | | 91 |
| 1950 | 14 | | | | | | 1 | | 1 | 12 | | | | 6 | 1 | 9 | | | | | | | 44 |
| 1951 | | | | | 30 | | | | | | | 29 | 8 | 14 | | | 11 | | | | | 1 | 93 |
| 1952 | | | | | | | 20 | | | | | | | 35 | | | | | | | 7 | | 62 |
| 1953 | | 14 | | 6 | | | | | | 3 | | | | 6 | | | | | | | 1 | | 30 |
| 1954 | | | | | | | 1 | | 1 | | | | | | | | | | | | | 1 | 3 |
| 1955 | | | | | | | 20 | | | | | | | | | | | | | | | | 20 |
| 1956 | 1 | | 4 | | | | 6 | | | 23 | | 9 | | 9 | 2 | 37 | 1 | | | | | | 92 |
| 1957 | | | | | | | 3 | | 8 | | | | | | | | | | | | | | 11 |
| 1958 | 12 | | | 3 | | | 15 | | | | | 14 | | 4 | 4 | 3 | | | 1 | | | | 56 |
| 1959 | | | | | | | 39 | | | | 31 | | | 22 | | | 2 | | 9 | | | | 103 |
| 1960 | 17 | | | | | | 11 | | 1 | | 89 | 21 | 1 | 5 | | | | 4 | | | | | 149 |
| 1961 | | | | | | | 18 | | | | 26 | 7 | | | | | | | | | | | 51 |
| 1962 | | | | | | | | | | | 53 | | | 1 | | | | 7 | | | | | 61 |
| 1963 | 25 | | | | | 1 | 5 | 1 | 1 | 1 | 17 | 2 | 1 | | | | 4 | 4 | | | | | 62 |
| 1964 | | | | | 3 | | 16 | | | | 16 | | 2 | | | | 19 | 1 | | | | | 57 |
| 1965 | 1 | | | | | | 5 | | | 1 | 7 | | 1 | 1 | | | 1 | 1 | | | | | 18 |
| 1966 | 1 | | | | | | 1 | | | 1 | | | | | | | 12 | 1 | | | | | 16 |
| 1967 | | | | 1 | | | 27 | | | | | | | 2 | | | 3 | | | | | | 33 |
| 1968 | 1 | | | | | | 8 | | 6 | | | | | | | | | | | | | | 15 |
| 1969 | 3 | | | | | 1 | 3 | | | 3 | | 14 | | 1 | | | 1 | | | | | | 26 |
| 1970 | | | | | | 1 | 10 | | | 18 | | 23 | | | | | | 2 | | | | | 54 |
| 1971 | 8 | | | | 1 | 3 | 36 | | 1 | 7 | | | | | | 12 | | 22 | | | | | 90 |
| 1972 | 5 | | 3 | | | 3 | 29 | 1 | 1 | 3 | | | 11 | 1 | | 4 | 5 | 2 | | | | | 68 |
| 1973 | | | | | 16 | | 2 | 7 | | 39 | | 40 | | | | 1 | | 14 | | | | | 119 |
| 1974 | 6 | | | | 9 | | 45 | | | 8 | | | | | | 14 | 13 | 3 | | | | | 98 |
| 1975 | | | | | | 1 | 12 | | | 13 | | 1 | 5 | 4 | 4 | 10 | 18 | | | | | | 68 |
| 1976 | | | | | 7 | | 3 | 8 | | 20 | | | 12 | | 5 | | 1 | | | | | | 56 |
| 1977 | | | | | | | 1 | | | 1 | | 79 | | | | 11 | | | | | | | 92 |
| 1978 | 3 | | | 6 | | | 17 | 18 | | 4 | | 8 | 5 | 22 | | 82 | 8 | | | | | | 173 |
| 1979 | 2 | | | | | | 11 | | | 13 | | 3 | | 4 | | 15 | 13 | | | | | | 61 |
| 1980 | 13 | 13 | | 12 | 16 | 2 | 3 | | | 18 | | 6 | 32 | | | | 67 | | | | | | 182 |
| 1981 | | | | 8 | 6 | | 5 | | 1 | | | 5 | 14 | | | 19 | 20 | 18 | | | | | 96 |
| 1982 | | | | | | | 15 | 3 | | | | | 16 | | | 7 | 1 | 11 | | | | | 53 |
| 1983 | | | | | 7 | | 7 | | | | | | | | | 4 | 10 | | | | | | 28 |
| 1984 | | | | | | | 53 | | | | | | | 5 | | 71 | | | | | | | 129 |
| 1985 | 2 | | | 49 | 3 | | 8 | | | | | 41 | | | 3 | 16 | 42 | 45 | | | | 2 | 211 |
| 1986 | 16 | | 1 | | | 11 | 4 | | 4 | | | 1 | 5 | | 4 | 11 | | | | | | 14 | 71 |
| 1987 | | | 9 | 1 | 10 | | 14 | | | | | 2 | | 4 | | 13 | 1 | | | | | | 54 |
| 1988 | | | | | | | 1 | | | 1 | | | | | | | | | | | | | 2 |
| 1989 | 125 | | | | 4 | | 15 | | | | | | 9 | | | 7 | | 41 | | | | | 201 |
| 1990 | | | | 10 | | | 2 | 13 | | | | | | | | 71 | 9 | | | | | | 105 |
| 1991 | | | | | 23 | | 5 | | | | | | | | | 40 | 1 | | | | | | 69 |
| Total | 339 | 27 | 38 | 96 | 152 | 28 | 648 | 64 | 154 | 211 | 239 | 329 | 173 | 147 | 34 | 500 | 296 | 226 | 14 | 21 | 17 | 18 | 3,771 |

Nuc.=Nuclear radiation. Indiv.=Unsafe for certain individuals. Mktg.=Marketing. Red.=Unannounced reductions in nutritional value.

Figure 1
**Food safety paragraphs, by major category and year**

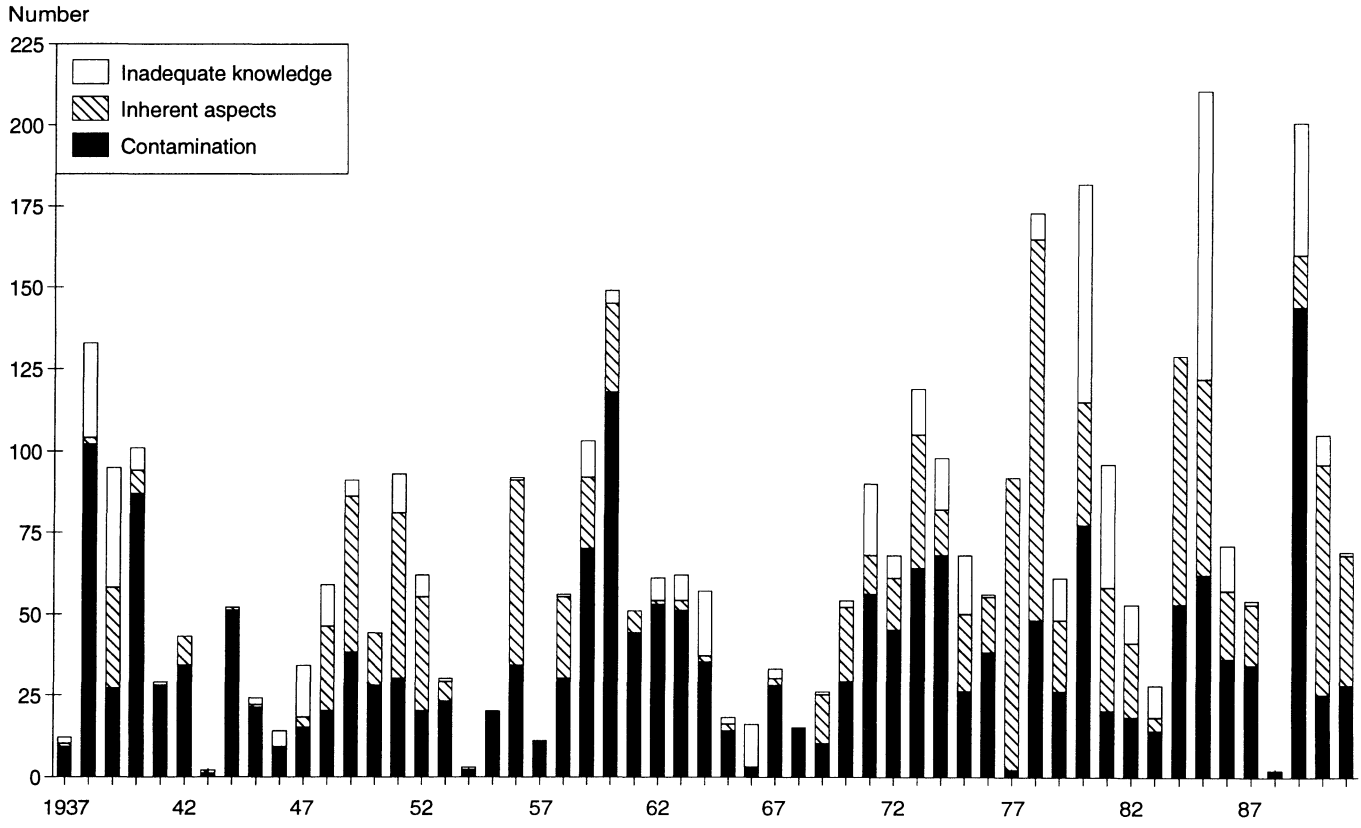


Figure 2
**Food safety paragraphs, by issue, 1937-91 and 1987-91**

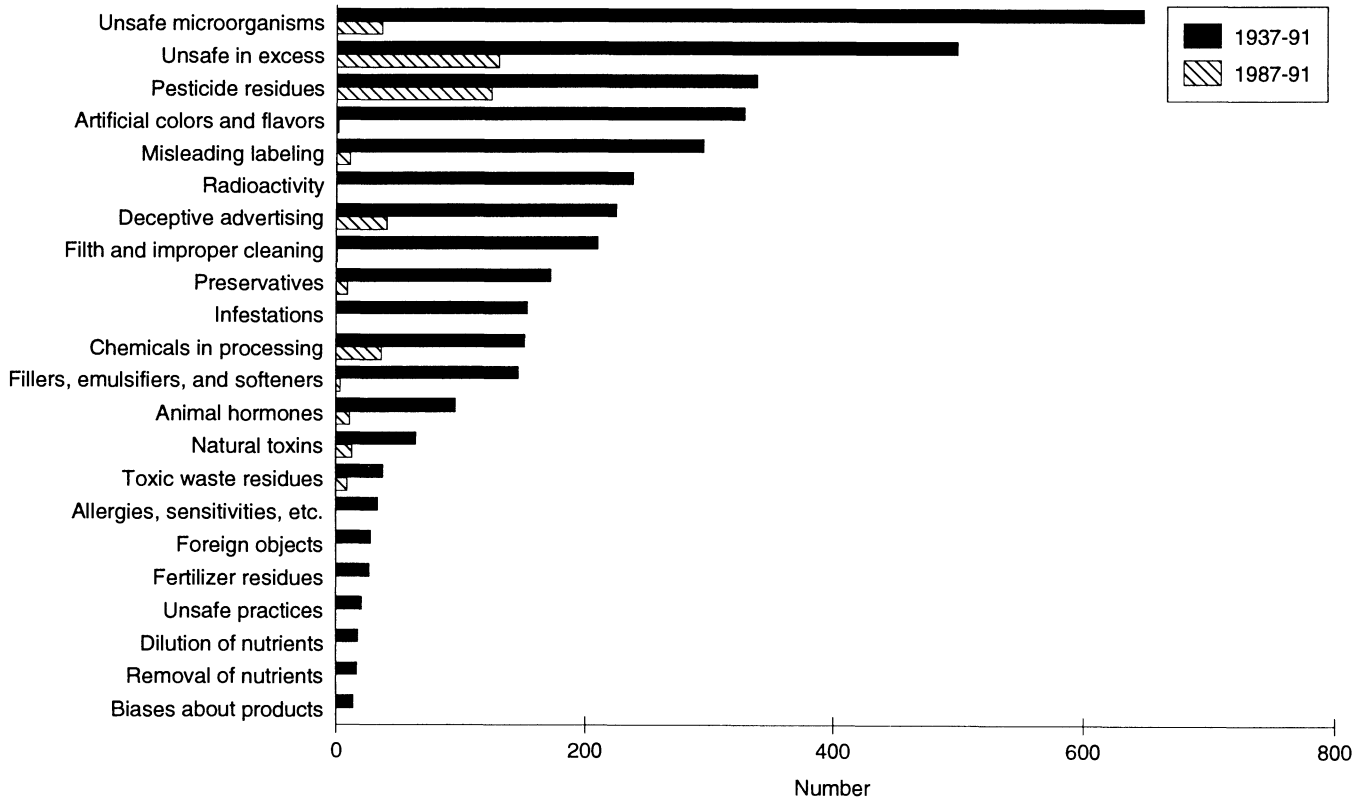

**Table 3–Examples of some of the most important food safety concerns according to *Consumer Reports*, 1937-91**

| Year | Food safety concern |
|---|---|
| 1938 | Lead in food, especially from lead arsenate as a pesticide and treatment for fruit. |
| 1939 | Food poisoning, due to bacterial contamination (such as salmonella and botulism). |
| 1940 | Trichinosis in undercooked pork. |
| 1941 | Potential hazards of drinking unpasteurized milk (such as brucellosis). |
| 1947 | Overstatement of nutritional benefits of yeast. |
| 1948 | Hazards in using nitrogen trichloride to bleach flour for white bread. |
| 1956 | Tooth decay caused by soft drinks. |
| 1958 | Potential hazards of chemical sweeteners. |
| 1959 | Radioactive fallout and its effect on the food supply, especially milk. |
| | Inadequate inspection of poultry. |
| 1960 | Use of chemical additives in food and the role of the Food and Drug Administration in establishing usage guidelines. |
| 1961 | Bacterial contamination in fish. |
| 1963 | False and exaggerated claims on the benefits of unsaturated fats and oils. |
| 1968 | High bacteria counts and amount of filth in pork products. |
| 1971 | Adverse health effects of caffeine in coffee. |
| 1972 | Nitrites in pork products. |
| 1973 | Safety of red food coloring. |
| 1974 | Presence of naturally occurring cyanide in certain hazardous vitamin tablets. |
| 1976 | Aflatoxin in peanut butter. |
| 1977 | Safety of saccharine. |
| 1978 | Too much added sugar in foods. |
| 1985 | The issue of salt and its link to high blood pressure. |
| | Antibiotics in animal feed. |
| 1987 | Chemicals found in bottled water. |
| 1989 | Presence of Alar in apples. |
| | Pesticide residues in produce. |
| 1991 | Dioxin in coffee filters. |

*Consumer Reports* in relation to seafood, poultry, beef, or pork products during 1937-91.[3] Tables 4-7 present summaries of the numbers of paragraphs found on beef, pork, poultry and seafood, respectively, for the safety issues and years for which there was at least one paragraph. One of the most noteworthy totals was the 71 paragraphs in 1940 on pork. The bulk of the total came from two lengthy articles published in March and April about trichinosis. In 1959 ineffective poultry inspection was the center of attention. Seafood received the most attention in 1961 in an exposé about bacteria found in frozen fish sticks and shrimp.[4] From 1976 to 1982, nitrites in pork products was the most discussed issue. By 1990, beef was the product receiving the most criticism, cumulating in a lengthy article titled "The Trouble with Hamburgers."

The data on individual paragraphs about beef, pork, poultry, and seafood were converted to data on detailed news stories (DNS) (see the earlier discussion), as shown in table 8. The paragraphs for DNS's were summed for each year across the safety issues pertaining to each product, rendering the totals displayed in the last column of the table. The effects of safety information were analyzed using only these totals. However, the separate effects of individual safety issues on consumption are likely to exist, and might

[3]In the tabulation of paragraphs, those that referred to "franks" or "hot dogs" were counted under pork products unless there was a specific reference to other types of franks. However, processed mixtures of products that contained relatively small quantities of the product in question, like cans of pork and beans or chicken soup, were not included, nor were any forms of pet food.

[4]Also see the February 1992 issue of *Consumer Reports* for risk information about seafood.

**Table 4–Food safety paragraphs on beef in *Consumer Reports*, by year and food safety issue**

| Table 1 category | Safety issue | Year (19___) 60 | 63 | 65 | 71 | 80 | 84 | 90 | Total |
|---|---|---|---|---|---|---|---|---|---|
| | | *Number of paragraphs* | | | | | | | |
| IA4 | Animal hormones, antibiotics, etc. | | | | | 12 | | 10 | 22 |
| IB1 | Unsafe microorganisms | 11 | | | 12 | | 37 | | 60 |
| IB3 | Infestations (such as trichinosis) | 1 | 1 | | | | | | 2 |
| IIA2 | Unsafe additives--preservatives | 1 | | 1 | | | | | 2 |
| IIA3 | Unsafe additives--such as fillers, emulsifiers, and softeners | 5 | | | | | | | 5 |
| IIB2 | Unsafe in excess--such as sugar, caffeine, cholesterol and saturated fats | | | | | | | 24 | 24 |
| IIIA1 | Misleading labeling regarding health effects | | 1 | 1 | | | | | 2 |
| | Annual total | 18 | 2 | 2 | 12 | 12 | 37 | 34 | 117 |

**Table 5–Food safety paragraphs on poultry in *Consumer Reports*, by year and food safety issue**

| Table 1 category | Safety issue | Year (19___) 40 | 53 | 55 | 56 | 59 | 64 | 67 | 73 | 78 | 81 | 87 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *Number of paragraphs* | | | | | | | | | | | |
| IA1 | Pesticide residues (due to residues in feed) | | | | | | | | | 3 | | | 3 |
| IA4 | Animal hormones, antibiotics, etc. | | | | | | | | | 6 | 8 | 1 | 15 |
| IB1 | Unsafe microorganisms | | | 9 | 4 | 36 | 1 | | | 6 | | 14 | 70 |
| IB4 | Filth and improper cleaning | | 1 | | | | | | 3 | | | | 4 |
| IIA1 | Artificial colors and flavors | 1 | | | | | | | 1 | | | 2 | 4 |
| IIA3 | Unsafe additives--such as fillers, emulsifiers, and softeners | | | | | | | | | | | 4 | 4 |
| IIB2 | Unsafe in excess--such as sugar, caffeine, cholesterol and saturated fats | | | | | | | | 1 | | | | 1 |
| IIIA1 | Misleading labeling regarding health effects | | | | | | | 1 | | | | | 1 |
| | Annual total | 1 | 1 | 9 | 4 | 36 | 1 | 1 | 5 | 15 | 8 | 21 | 102 |

well be worth examining with more extensive data on historical media coverage.

In the statistical analysis of the effect of risk information (paragraphs in DNS's) on consumption (pounds consumed per capita), five factors were examined as determinants of consumption:

1. The *real prices* of beef, pork, poultry, and seafood, measured in terms of the ratio of the consumer price index for each product to the consumer price index for all products.

2. The number of DNS paragraphs published about the product, which is the *direct information effect.*

3. The interaction between risk information and time, measured as the product of the number of years and the number of DNS paragraphs. This measures the extent to which consumer response to risk information has changed systematically over time. It is the *evolutionary change in the effect of risk information.*

4. The year as a measure of historical or *evolutionary change in consumption patterns.*

5. *Real income*, per capita.

Details of the statistical findings are reported in the appendix. The following summarizes these results.

Evolutionary changes in the effect of risk information and in consumption patterns are concepts that are consistent with the notion of *economic evolution*, whereby agents (in this case consumers) undergo adjustments over time in response to their physical and

**Table 6--Food safety paragraphs on pork in *Consumer Reports*, by year and food safety issue**

| Table 1 category | Safety issue | Year (19___) | | | | | | | | | | | | | | | | | | | Issue total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 40 | 44 | 45 | 49 | 57 | 58 | 63 | 66 | 67 | 68 | 70 | 72 | 76 | 78 | 80 | 81 | 82 | 86 | 89 | |
| | | *Number of paragraphs* | | | | | | | | | | | | | | | | | | | |
| IB1 | Unsafe microorganisms | | | | 1 | | 7 | | | | 7 | | 7 | 2 | | 3 | 1 | | | | 28 |
| IB3 | Infestations (such as trichinosis) | 71 | 1 | 8 | 5 | 8 | | | | | 6 | | | | | | 1 | | | | 100 |
| IB4 | Filth and improper cleaning | | | | | | | | | | | 11 | | 4 | | 4 | | | | | 19 |
| IIA1 | Unsafe additives: artificial colors and flavors | | | | | | | 1 | | | | | | | 1 | | | | 1 | | 3 |
| IIA2 | Unsafe additives: preservatives | | | | | | | | | | | | 10 | 12 | 2 | 32 | 14 | 16 | 5 | 9 | 100 |
| IIA3 | Unsafe additives: fillers, emulsifiers, softeners, and other additives | | | | | | 4 | | | 2 | | | 1 | | | | | | | | 7 |
| IIB2 | Unsafe if consumed in excess (such as sugar, caffeine, cholesterol, and saturated fats) | | | | | | | | | | | | | | | | | | 3 | 2 | 5 |
| IIIA1 | Misleading labeling regarding health effects | | | | | | | | 1 | | | | | 1 | | | | | | | 2 |
| IIIA2 | Deceptive advertising regarding health effects | | | | | | | | 1 | | | | | | | | | | | | 1 |
| IIIC2 | Dilution of nutritional components | | | | | | | | | | | | | | | | | | 14 | | 14 |
| | Total | 71 | 1 | 8 | 6 | 8 | 11 | 1 | 2 | 2 | 13 | 11 | 18 | 19 | 3 | 39 | 16 | 16 | 23 | 11 | 279 |

**Table 7--Food safety paragraphs on seafood in *Consumer Reports*, by year and food safety issue**

| Table 1 category | Safety issue | Year (19___) | | | | | | | | | | | | | | | | | | | | Issue total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 38 | 40 | 41 | 42 | 47 | 61 | 63 | 64 | 65 | 67 | 69 | 70 | 71 | 72 | 74 | 75 | 76 | 82 | 86 | 89 | |
| | | *Number of paragraphs* | | | | | | | | | | | | | | | | | | | | |
| IA1 | Pesticide residues | | | | | | | | | | | | | 2 | | | | | | 1 | | 3 |
| IA3 | Toxic waste residues | | | | | | | | | | | | | | 3 | | | | | 1 | | 4 |
| IA5 | Chemicals in processing operations | | | | | | | | 3 | | | | | | | | | 7 | | | | 10 |
| IA6 | Foreign objects (such as pieces of glass) | | | 1 | | | | | | | | | 1 | | | | | | | | | 2 |
| IB1 | Unsafe microorganisms | | | 1 | 2 | | 14 | 2 | 11 | 1 | 5 | 2 | 9 | | 5 | 3 | 1 | | 3 | 1 | 1 | 61 |
| IB3 | Infestations (such as trichinosis) | | | | | 1 | | | | | | | | | | | | | | 1 | | 2 |
| IB4 | Filth and improper cleaning | 1 | 2 | | | 3 | | | | | | | | | | 4 | 6 | 2 | | | | 18 |
| IIB1 | Unsafe for certain individuals due to allergies, sensitivities, and dietary ailments | | | | | | | | | | | | | | | | | | | 1 | | 1 |
| IIB2 | Unsafe if consumed in excess (such as sugar, caffeine, cholesterol, or saturated fats) | | | | | | | | | | | | | | | | | | | 1 | | 1 |
| | Total | 1 | 2 | 2 | 2 | 4 | 14 | 2 | 14 | 1 | 5 | 2 | 10 | 2 | 8 | 7 | 7 | 9 | 3 | 6 | 1 | 102 |

## Table 8–Paragraphs in detailed news stories, by food product and food safety issue

| | Table 1 category | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Beef | | | | Poultry | | Pork | | | | | Seafood | | | Totals | | | |
| Year | IA4 | IB1 | IIA3 | IIB2 | IA4 | IB1 | IB1 | IB3 | IB4 | IIA2 | IIIC2 | IA5 | IB1 | IB4 | Beef | Poultry | Pork | Seafood |
| | | | | | | | | | | *Number* | | | | | | | | |
| 1937 | | | | | | | | | | | | | | | | | | |
| 1938 | | | | | | | | | | | | | | | | | | |
| 1939 | | | | | | | | | | | | | | | | | | |
| 1940 | | | | | | | | 35.5 | | | | | | | | | 35.5 | |
| 1941 | | | | | | | | 35.5 | | | | | | | | | 35.5 | |
| 1942 | | | | | | | | | | | | | | | | | | |
| 1943 | | | | | | | | | | | | | | | | | | |
| 1944 | | | | | | | | | | | | | | | | | | |
| 1945 | | | | | | | | | | | | | | | | | | |
| 1946 | | | | | | | | | | | | | | | | | | |
| 1947 | | | | | | | | | | | | | | | | | | |
| 1948 | | | | | | | | | | | | | | | | | | |
| 1949 | | | | | | | | 2.5 | | | | | | | | | 2.5 | |
| 1950 | | | | | | | | 2.5 | | | | | | | | | 2.5 | |
| 1951 | | | | | | | | | | | | | | | | | | |
| 1952 | | | | | | | | | | | | | | | | | | |
| 1953 | | | | | | | | | | | | | | | | | | |
| 1954 | | | | | | | | | | | | | | | | | | |
| 1955 | | | | | | 6.5 | | | | | | | | | | 6.5 | | |
| 1956 | | | | | | 6.5 | | | | | | | | | | 6.5 | | |
| 1957 | | | | | | | | 4.0 | | | | | | | | | 4.0 | |
| 1958 | | | | | | | 3.5 | 4.0 | | | | | | | | | 7.5 | |
| 1959 | | | | | | 18.0 | 3.5 | | | | | | | | | 18.0 | 3.5 | |
| 1960 | | 5.5 | 2.5 | | | 18.0 | | | | | | | | | 8.0 | 18.0 | | |
| 1961 | | 5.5 | 2.5 | | | | | | | | | | 3.3 | | 8.0 | | | 3.3 |
| 1962 | | | | | | | | | | | | | 3.3 | | | | | 3.3 |
| 1963 | | | | | | | | | | | | | 3.3 | | | | | 3.3 |
| 1964 | | | | | | | | | | | | | 3.3 | | | | | 3.3 |
| 1965 | | | | | | | | | | | | | 3.3 | | | | | 3.3 |
| 1966 | | | | | | | | | | | | | 3.3 | | | | | 3.3 |
| 1967 | | | | | | | | | | | | | 3.3 | | | | | 3.3 |
| 1968 | | | | | | | 3.5 | 3.0 | | | | | 3.3 | | | | 6.5 | 3.3 |
| 1969 | | | | | | | 3.5 | 3.0 | | | | | 3.3 | | | | 6.5 | 3.3 |
| 1970 | | | | | | | | | 5.5 | | | | 3.3 | | | | 5.5 | 3.3 |
| 1971 | | 6.0 | | | | | | | 5.5 | | | | 3.3 | | 6.0 | | 5.5 | 3.3 |
| 1972 | | 6.0 | | | | | 3.5 | | | 5.0 | | | 3.3 | | 6.0 | | 8.5 | 3.3 |
| 1973 | | | | | | | 3.5 | | | 5.0 | | | 3.3 | | | | 8.5 | 3.3 |
| 1974 | | | | | | | | | | | | | 3.3 | 3.0 | | | | 6.3 |
| 1975 | | | | | | | | | | | | | 3.3 | 3.0 | | | | 6.3 |
| 1976 | | | | | | | | | | 9.5 | | 3.5 | 3.3 | 3.0 | | | 9.5 | 9.8 |
| 1977 | | | | | | | | | | 9.5 | | 3.5 | | 3.0 | | | 9.5 | 6.5 |
| 1978 | | | | | 3.0 | 3.0 | | | | 9.5 | | | | | | 6.0 | 9.5 | |
| 1979 | | | | | 3.0 | 3.0 | | | | 9.5 | | | | | | 6.0 | 9.5 | |
| 1980 | 6.0 | | | | | | | | | 9.5 | | | | | 6.0 | | 9.5 | |
| 1981 | 6.0 | | | | 4.0 | | | | | 9.5 | | | | | 6.0 | 4.0 | 9.5 | |
| 1982 | | | | | 4.0 | | | | | 9.5 | | | | | | 4.0 | 9.5 | |
| 1983 | | | | | | | | | | 9.5 | | | | | | | 9.5 | |
| 1984 | | 18.5 | | | | | | | | | | | | | 18.5 | | | |
| 1985 | | 18.5 | | | | | | | | | | | | | 18.5 | | | |
| 1986 | | | | | | | | | | 2.5 | 7.0 | | | | | | 9.5 | |
| 1987 | | | | | | 7.0 | | | | 2.5 | 7.0 | | | | | 7.0 | 9.5 | |
| 1988 | | | | | | 7.0 | | | | | | | | | | 7.0 | | |
| 1989 | | | | | | | | | | 4.5 | | | | | | | 4.5 | |
| 1990 | 5.0 | | | 12.0 | | | | | | 4.5 | | | | | 17.0 | | 4.5 | |
| 1991 | 5.0 | | | 12.0 | | | | | | | | | | | 17.0 | | | |

social surroundings. Such change is seen by evolutionary economists as endogenous, that is, having a scientific or deterministic basis. For example, Nelson and Winter write:

> The broader connotations of "evolutionary" include a concern with processes of long-term and progressive change. The regularities observable in present reality are interpreted not as a solution to a static problem, but as the result that understandable dynamic processes have produced from known or plausibly conjectured conditions in the past and also as features of the stage from which a quite different future will emerge by those same dynamic processes. In this sense, all of the natural sciences are today evolutionary in fundamental respects (p. 10).

One could also think of goods and services as evolving. That is, they change systematically over time in terms of their physical characteristics, the technologies used to produce them, and the perception or demand that consumers have toward them (Payson, 1994).

The effects of prices on consumption can be subdivided into two effects: how the price of a product affects the consumption of that same product (*own-price* effect) and how it affects the consumption of a different product (*cross-price* effect). In general, own-price effects are expected to be negative (consumers purchase less of product when its price rises). For substitutes, cross-price effects are usually positive (consumers purchase more of a product when the price of its substitute rises). The results obtained in this study reveal a strong and highly significant negative own-price effect for beef, pork, and poultry consumption. Neither a significant own-price effect nor a cross-price effect was found for seafood, which may be attributable to the wide variety of seafood in existence, which, at the outset, calls into question the meaningfulness of a single price for seafood. Cross-price effects between beef and pork were positive and highly significant, as was the cross-price effect of the price of seafood on pork consumption. In contrast, the price of poultry had an unexpected significant negative effect on beef consumption.[5] Real income per capita was found to be a highly significant determinant of beef, poultry, and pork consumption but not of seafood consumption.

Evolutionary change in consumption patterns, defined by the relationship between the quantities consumed and the years in which they were consumed, was found to be highly significant for all four products. Consumption of beef and pork decreased over time, and their consumption would have declined substantially more with each passing year if all of the other variables remained constant. In contrast, consumption of poultry and seafood increased. These trends could result from evolutionary changes in the quality of the products or in consumer tastes. They could also result from changes in the productive capabilities of firms, where productivity is not already translated into price changes (otherwise the trends would show up as price effects). Recent studies of beef, pork, poultry, and seafood have found evidence of a change in consumer tastes and preferences, particularly with respect to poultry (Eales and Unnevehr, 1988).

For each of the four products, the net effect of risk information on consumption was defined as the estimated coefficient for information times the average level of information, plus the estimated coefficient for evolutionary interaction times the average level of evolutionary interaction, where evolutionary interaction is the product of information and time (see appendix). In this sense, the net effect of information can be interpreted as a combination of two effects: a direct effect and an evolutionary effect.

For beef, a small, negative net effect was observed, which was the result of a negative evolutionary effect and positive direct effect that tended to cancel each other out. The negative evolutionary effect of risk information on beef consumption suggests that media coverage of safety information has had a growing negative influence on beef consumption. Over time, this evolutionary effect tends to dominate, rendering a greater negative net effect of information overall. The positive direct effect reinforces the tendency for the overall net effect to be less negative in earlier years and more negative in later years.[6] However, while the individual direct and evolutionary effects were each statistically significant, the combined net effect was not.

For seafood, the net effect of information, accounting for both direct and evolutionary effects, was also nega-

[5]Other studies of meat demand have found evidence of a changing relationship between beef and poultry (Chavas, 1983). This counterintuitive finding probably reflects underlying changes in preferences that have not been fully accounted for by the explanatory variables.

[6]A positive direct effect may dominate over a negative evolutionary effect in earlier years, rendering a positive net effect for those years. Conversely, a positive evolutionary effect may dominate over a negative direct effect in later years, rendering a positive net effect for those years. In the present study some positive net effects were observed within certain time intervals, but these effects were extremely small and could not be distinguished from zero in terms of statistical significance.

tive, where the individual effects were each statistically significant while the combined net effect was not. In this case the evolutionary effect was positive, and the direct effect was negative. In contrast to beef, seafood does not undergo as much change over time in the mix of safety issues covered because all issues covered fall under the same broad category of contamination. Consequently, one explanation for the positive evolutionary effect, in juxtaposition to the negative direct effect, may be that consumers might become somewhat desensitized to the same risk information about seafood over time. That is, risk information on the same issue could continue to have a negative direct effect, but the magnitude of the effect could become smaller over time. Another possibility is that the aggregate product has evolved into a safer product, with several of the specific products within that aggregate having less contamination. In this case, a repetition of the same safety warnings would apply to fewer and fewer of the items falling under the seafood aggregate. To the extent that this trend is noticed by consumers, the same amount of risk information will become less important over time. As an example, if seafood contains, over time, higher proportions of farmed fish as opposed to caught fish, then the relative importance of contaminated oceans with regard to food safety would decline.

The direct and evolutionary effects of risk information on poultry consumption and on pork consumption were not statistically significant, suggesting that consumption of these products may not be responsive to risk information. The risk information on pork is much more extensive than that on poultry, in both quantity and diversity of DNS paragraphs. Given these circumstances, it is more likely that pork consumption is, in fact, less responsive to risk information than beef and seafood consumption. Nevertheless, this hypothesis would need to be confirmed through the examination of additional media sources.

Another factor that must also be considered is that, depending on the nature of the risk involved and the manner in which it is handled by the media, consumers may respond to risk information by substituting among products within a particular product type rather than among different product types. For instance, if certain brands of canned tuna are found to be contaminated, consumers may switch to other brands of canned tuna, to canned salmon, or to fresh or frozen fish, as opposed to switching to chicken, pork, or beef. Consequently, consumer responses to risk are much greater than what can be observed from an examination of large categories of foods. The same argument would also apply for the observed price and income effects.

## Conclusion

Historical sources of media coverage, such as *Consumer Reports*, provide researchers in the area of food safety with valuable information about longrun trends. In particular, trends can be identified regarding the attention that various food safety issues receive, the consumption and production patterns of society, and the interrelationships that exist among these patterns of attention and consumption. The data from *Consumer Reports* alone show that consumer concern about food safety has been increasing since the late 1970's. Concern about unsafe microorganisms in food declined, while attention to foods unsafe when consumed in excess (such as food high in saturated fats) has gained ground. Pesticide residues in food have also received much more attention recently than in the past, as have concerns over the accuracy and depth of the information provided by manufacturers about their products. A general shift has occurred from acute food safety problems to chronic ones, such as from problems like trichinosis and botulism to problems like unwanted cholesterol and preservatives.

While historical documents have their own unique advantages in terms of the robustness and evolutionary qualities of the data they provide, they also have their own unique set of difficulties in measurement and interpretation. Perhaps the greatest difficulty for the researcher is distinguishing between media coverage that is random or sporadic and that which represents the concerns of most consumers and media sources when the food safety article is published. To isolate systematic coverage from sporadic coverage, a measurement technique was developed that identified DNS's. A DNS contains a minimum number of total paragraphs on the same safety issue and food product within a consecutive set of years. The information conveyed in DNS's was likely to be provided by media sources other than *Consumer Reports* at roughly the same time. The reclassification of risk information in terms of DNS's facilitated the statistical analysis of longrun trends in the consumption of beef, pork, poultry, and seafood.

For beef, a negative net effect of information was observed. This consisted of a highly significant, negative evolutionary effect, in which the impact of media coverage per paragraph was found to increase over time, all else being equal. A negative net effect of information was also observed for seafood, but

with a positive evolutionary effect. This suggested that media coverage per paragraph became relatively less important over time in the case of seafood. Significant evolutionary effects were not observed for poultry or pork products. These differences in information effects across product types could be due to differences in the nature of the safety information pertaining to these types, differences in consumer behavior toward these products, or differences in the evolutionary changes experienced by the products themselves.

The results imply that the effect of food safety information on consumption may not be proportional to the amount of media coverage or the hazardousness of the health problem in question. That is, a simple price premium per additional unit (or higher probability) of hazard avoided may not be appropriate because the importance of the hazard to the consumer is a function of the particular food product in question. Consequently, a hedonic approach to risk that uses the characteristics of goods as variables should also distinguish among food types (such as beef, pork, poultry, and seafood) in order to predict behavioral changes in response to risk changes. An alternative, evolutionary approach that also preserves the uniqueness of alternative foods could be applied as well. In such studies, the direct and evolutionary effects of risk information could be useful concepts that enable economists to measure the differential effect of risk on the demand for different foods (see appendix).

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## Appendix: An Extended Economic Model of U.S. Meat Consumption

A typical model of U.S. meat consumption, such as the double-log model presented in Pope and others, has consumption as the dependent variable and prices and income as the independent variables:

$$C^{bf}=\beta_{1,0}+\beta_{1,1}P^{bf}+\beta_{1,2}P^{pk}+\beta_{1,3}P^{pl}+\beta_{1,4}P^{sf}+\beta_{1,5}I$$
$$C^{pk}=\beta_{2,0}+\beta_{2,1}P^{bf}+\beta_{2,2}P^{pk}+\beta_{2,3}P^{pl}+\beta_{2,4}P^{sf}+\beta_{2,5}I$$
$$C^{pl}=\beta_{3,0}+\beta_{3,1}P^{bf}+\beta_{3,2}P^{pk}+\beta_{3,3}P^{pl}+\beta_{3,4}P^{sf}+\beta_{3,5}I$$
$$C^{sf}=\beta_{4,0}+\beta_{4,1}P^{bf}+\beta_{4,2}P^{pk}+\beta_{4,3}P^{pl}+\beta_{4,4}P^{sf}+\beta_{4,5}I$$

where *bf* refers to beef, *pk* to pork, *pl* to poultry, *sf* to seafood, *C* to consumption (in the log of pounds per capita), *P* to the real price (in the log of constant dollars), *I* to the real income (in logs). The β's are the coefficients to be estimated.

To take account of information, the above model can be rewritten with the addition of three new independent variables:

$$C^{bf}=\beta_{1,0}+\beta_{1,1}P^{bf}+\beta_{1,2}P^{pk}+\beta_{1,3}P^{pl}+\beta_{1,4}P^{sf}+\beta_{1,5}I+\beta_{1,6}R^{bf}+\beta_{1,7}T+\beta_{1,8}E^{bf}$$
$$C^{pk}=\beta_{2,0}+\beta_{2,1}P^{bf}+\beta_{2,2}P^{pk}+\beta_{2,3}P^{pl}+\beta_{2,4}P^{sf}+\beta_{2,5}I+\beta_{2,6}R^{pk}+\beta_{2,7}T+\beta_{2,8}E^{pk}$$
$$C^{pl}=\beta_{3,0}+\beta_{3,1}P^{bf}+\beta_{3,2}P^{pk}+\beta_{3,3}P^{pl}+\beta_{3,4}P^{sf}+\beta_{3,5}I+\beta_{3,6}R^{pl}+\beta_{3,7}T+\beta_{3,8}E^{pl}$$
$$C^{sf}=\beta_{4,0}+\beta_{4,1}P^{bf}+\beta_{4,2}P^{pk}+\beta_{4,3}P^{pl}+\beta_{4,4}P^{sf}+\beta_{4,5}I+\beta_{4,6}R^{sf}+\beta_{4,7}T+\beta_{4,8}E^{sf}$$

where *R* is the risk information paragraphs in DNS's about the product in question, *T* is time (the year), and *E* is the evolutionary interaction between between *R* and *T*, defined as *R* times *T*. The above system was estimated using a generalized least squares technique, with corrections for first-order autocorrelation. The years 1942-45 were excluded from this analysis to avoid any misspecifications of the structural changes occurring as a result of U.S. involvement in World War II. The data are in appendix table 1, and the results of the regression analysis are in appendix table 2.

The evolutionary factor (*E*) tests whether the effect of information (*R*) on consumption can change systematically over time. For example, one could write:

$$C=f(R^*);\quad R^*=Re^{rT}$$

where the effect of information increases at a rate of *r* per period.

When relationships of this kind exist, *r* is often estimated by regressing logs of the variables in question, since a linear relationship is established:

$$\log R^*=\log R+rT$$

However, the presence of zero values of *R* preclude this type of analysis. For small rates of change, one could use the approximation:

$$R^*=(T-T_0)R$$

for some $T_0$ such that

$$\frac{(T+1)-T_0}{T-T_0}\approx 1+r$$

## Appendix table 1--Price, consumption, and income data used in the analysis

| Year | Consumer Price Index | | | | Per capita income | Per capita consumption (boneless, trimmed equivalent) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Beef[1] | Pork | Poultry | Seafood | | Beef[1] | Pork | Poultry | Seafood |
| | 1982-84=100 | | | | 1987 dollars | Pounds | | | |
| 1937 | 12.5 | 15.7 | 39.9 | 6.3 | 6,230 | 39.1 | 44.1 | 11.2 | 11.8 |
| 1938 | 11.6 | 14.2 | 39.7 | 6.4 | 5,866 | 38.5 | 45.6 | 10.6 | 10.8 |
| 1939 | 11.9 | 13.1 | 35.6 | 6.3 | 6,317 | 38.7 | 50.8 | 11.7 | 10.7 |
| 1940 | 12.1 | 11.8 | 36.0 | 6.9 | 6,799 | 38.9 | 55.0 | 12.0 | 11.0 |
| 1941 | 13.0 | 14.7 | 38.8 | 7.8 | 7,815 | 43.1 | 51.8 | 12.9 | 11.2 |
| 1942 | 14.5 | 17.7 | 46.6 | 10.2 | 8,728 | 43.3 | 48.9 | 14.6 | 8.7 |
| 1943 | 14.6 | 17.7 | 55.5 | 13.0 | 9,744 | 37.8 | 58.3 | 18.0 | 7.9 |
| 1944 | 13.9 | 16.5 | 57.3 | 13.0 | 10,321 | 39.4 | 58.6 | 16.2 | 8.7 |
| 1945 | 13.9 | 16.6 | 58.7 | 13.6 | 10,032 | 42.0 | 50.7 | 17.7 | 9.9 |
| 1946 | 17.7 | 21.8 | 66.0 | 14.8 | 8,740 | 43.6 | 56.4 | 16.3 | 10.8 |
| 1947 | 25.1 | 31.8 | 69.6 | 17.0 | 8,499 | 49.1 | 52.6 | 15.3 | 10.3 |
| 1948 | 30.4 | 32.8 | 77.1 | 19.6 | 8,728 | 44.6 | 51.5 | 15.1 | 11.1 |
| 1949 | 28.3 | 30.3 | 72.7 | 19.7 | 8,586 | 45.2 | 51.4 | 16.1 | 10.9 |
| 1950 | 31.2 | 29.9 | 69.6 | 19.4 | 9,258 | 44.8 | 52.3 | 17.5 | 11.8 |
| 1951 | 36.5 | 31.7 | 73.0 | 22.1 | 9,823 | 39.7 | 54.0 | 18.4 | 11.2 |
| 1952 | 36.2 | 31.4 | 73.2 | 21.5 | 9,949 | 44.0 | 54.3 | 19.0 | 11.2 |
| 1953 | 28.5 | 35.0 | 71.4 | 20.7 | 10,226 | 54.7 | 48.8 | 18.9 | 11.4 |
| 1954 | 27.4 | 36.1 | 64.5 | 20.9 | 9,906 | 56.5 | 46.7 | 19.9 | 11.2 |
| 1955 | 27.1 | 31.0 | 67.1 | 20.4 | 10,475 | 58.0 | 50.6 | 18.6 | 10.5 |
| 1956 | 26.7 | 29.5 | 58.8 | 20.4 | 10,483 | 60.3 | 51.3 | 20.9 | 10.4 |
| 1957 | 28.7 | 33.9 | 57.3 | 20.7 | 10,443 | 59.5 | 46.7 | 22.3 | 10.2 |
| 1958 | 33.4 | 36.2 | 56.7 | 22.1 | 10,155 | 56.7 | 45.6 | 24.0 | 10.6 |
| 1959 | 34.4 | 32.2 | 51.6 | 22.5 | 10,968 | 57.2 | 51.1 | 24.9 | 10.9 |
| 1960 | 33.5 | 32.0 | 52.5 | 22.5 | 10,982 | 59.8 | 48.9 | 24.1 | 10.3 |
| 1961 | 33.0 | 33.5 | 47.4 | 23.0 | 11,097 | 61.8 | 47.1 | 26.7 | 10.7 |
| 1962 | 34.2 | 33.8 | 50.1 | 24.0 | 11,496 | 62.5 | 47.7 | 26.2 | 10.6 |
| 1963 | 33.8 | 32.9 | 49.3 | 23.9 | 11,803 | 66.3 | 48.9 | 26.6 | 10.7 |
| 1964 | 32.8 | 32.8 | 48.2 | 23.4 | 12,301 | 70.5 | 49.2 | 27.3 | 10.5 |
| 1965 | 34.4 | 37.3 | 49.7 | 24.1 | 12,822 | 70.5 | 43.8 | 28.9 | 10.8 |
| 1966 | 36.2 | 42.7 | 52.4 | 25.6 | 13,425 | 73.8 | 43.1 | 30.9 | 10.9 |
| 1967 | 36.4 | 39.1 | 49.1 | 26.5 | 13,624 | 75.5 | 47.4 | 32.1 | 10.6 |
| 1968 | 37.9 | 39.2 | 50.6 | 26.9 | 14,047 | 77.5 | 48.7 | 31.7 | 11.0 |
| 1969 | 41.7 | 42.7 | 53.5 | 28.4 | 14,280 | 77.7 | 47.5 | 33.0 | 11.2 |
| 1970 | 43.5 | 45.4 | 53.2 | 31.3 | 14,109 | 79.8 | 48.5 | 34.1 | 11.7 |
| 1971 | 45.5 | 41.1 | 53.5 | 34.5 | 14,345 | 79.2 | 53.0 | 34.3 | 11.5 |
| 1972 | 49.7 | 47.6 | 54.2 | 37.6 | 14,904 | 80.5 | 48.1 | 35.8 | 12.5 |
| 1973 | 59.6 | 63.3 | 76.0 | 43.1 | 15,564 | 75.9 | 43.2 | 34.1 | 12.7 |
| 1974 | 61.3 | 63.0 | 72.1 | 49.7 | 15,346 | 80.7 | 47.0 | 34.2 | 12.1 |
| 1975 | 61.9 | 77.1 | 79.7 | 53.9 | 15,037 | 83.2 | 38.4 | 33.3 | 12.1 |
| 1976 | 59.9 | 78.1 | 76.4 | 60.2 | 15,646 | 89.0 | 41.0 | 35.9 | 12.9 |
| 1977 | 59.5 | 73.9 | 76.9 | 66.7 | 16,201 | 86.6 | 42.6 | 36.6 | 12.6 |
| 1978 | 73.1 | 83.4 | 84.9 | 73.0 | 16,794 | 82.4 | 42.8 | 37.8 | 13.4 |
| 1979 | 93.1 | 84.7 | 89.1 | 80.1 | 17,082 | 73.7 | 49.1 | 40.5 | 13.0 |
| 1980 | 98.4 | 81.9 | 93.7 | 87.5 | 16,790 | 72.2 | 52.6 | 41.1 | 12.4 |
| 1981 | 99.2 | 89.5 | 97.5 | 94.8 | 16,890 | 72.9 | 50.4 | 42.4 | 12.6 |
| 1982 | 100.6 | 101.0 | 95.8 | 98.2 | 16,348 | 72.7 | 45.3 | 42.5 | 12.4 |
| 1983 | 99.1 | 100.1 | 97.0 | 99.3 | 16,813 | 74.2 | 47.9 | 43.0 | 13.3 |
| 1984 | 100.3 | 98.8 | 107.3 | 102.5 | 17,659 | 74.0 | 47.7 | 44.1 | 14.1 |
| 1985 | 98.2 | 99.1 | 106.2 | 107.5 | 18,007 | 74.7 | 48.1 | 45.7 | 15.0 |
| 1986 | 98.8 | 107.2 | 114.2 | 117.4 | 18,337 | 74.5 | 45.6 | 47.6 | 15.4 |
| 1987 | 106.3 | 116.0 | 112.6 | 129.9 | 18,713 | 69.7 | 46.0 | 51.1 | 16.1 |
| 1988 | 112.1 | 112.5 | 120.7 | 137.4 | 19,284 | 68.7 | 49.2 | 52.1 | 15.1 |
| 1989 | 119.3 | 113.2 | 132.7 | 143.6 | 19,566 | 65.6 | 48.8 | 54.1 | 15.6 |
| 1990 | 129.0 | 129.8 | 133.0 | 146.7 | 19,579 | 64.1 | 46.7 | 56.4 | 15.0 |
| 1991 | 132.0 | 134.1 | 132.0 | 148.3 | 19,235 | 63.3 | 47.3 | 58.5 | 14.8 |

Sources: Consumer price indices from U.S. Department of Labor, Bureau of Labor Statistics; income per capita from *Statistical Abstract of the United States, 1992* and *Historical Statistics of the United States, 1975*; and consumption data from U.S. Department of Agriculture, Economic Research Service.

[1]Includes veal, although consumption data refer only to beef. A price index for beef alone was not available.

## Appendix table 2--Results of the generalized-least-squares (GLS) regression analysis of meat consumption[1]

| Dependent variable (consumption per capita in pounds) | Coefficients and t-Statistics: Constant | Consumer Price Index (CPI for all goods, in logs): Beef | Pork | Poultry | Seafood | Risk information about the dependent variable | Interaction of risk information and year | Year | Income per capita, in logs | Rho used for GLS | Adjusted R-squared | Durbin-Watson statistic |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Beef | 41.33 | -0.3045 | 0.7636 | -0.6151 | -0.1547 | 0.8777 | -0.4432E-03 | -0.02520 | 1.330 | 0.2397 | 0.9378 | 1.589 |
| | (3.217) | (-2.770) | (7.424) | (-4.335) | (-0.924) | (2.582) | (-2.586) | (-3.539) | (6.105) | | | |
| Pork | 27.27 | 0.2099 | -0.6945 | 0.05225 | 0.3208 | -0.006488 | 0.3089E-05 | -0.01348 | 0.3391 | 0.3215 | 0.8276 | 1.709 |
| | (4.201) | (3.515) | (-12.42) | (0.719) | (3.595) | (-0.079) | (0.073) | (-3.706) | (2.809) | | | |
| Poultry | -24.64 | 0.06217 | -0.003471 | -0.2420 | 0.1450 | 0.05059 | -0.2684E-04 | 0.01200 | 0.4786 | 0.4633 | 0.9925 | 1.484 |
| | (-3.014) | (0.793) | (-0.049) | (-2.660) | (1.246) | (0.190) | (-0.197) | (2.616) | (3.058) | | | |
| Seafood | -27.55 | -0.1156 | -0.1048 | 0.2065 | -0.08979 | -2.634 | 0.001335 | 0.01614 | -0.1910 | 0.3926 | 0.8268 | 1.686 |
| | (-2.508) | (-1.122) | (-1.106) | (1.681) | (-0.602) | (-1.982) | (1.982) | (2.616) | (-0.932) | | | |

[1]The statistical package LIMDEP was used to perform this analysis.

for all $T$ in the range examined. In this case, one ends up with two variables on the righthand side: ($TR$) and ($T_0R$). If $R$ is an exogenous variable, then the estimated coefficient for $R$ would reflect the sum of two components: the independent effect of $R$ itself, and the role of ($T_0R$) in the evolutionary effect of [$(T-T_0)R$].

The net effect of information on consumption is defined as:

$$\textit{Net effect} \equiv \hat{\beta}_{.,6}\,\bar{R} + \hat{\beta}_{.,8}\bar{E}$$

where $\hat{\beta}_{.,6}$ and $\hat{\beta}_{.,8}$ are estimated coefficients for information and evolutionary interaction (the product of information and year), and $\bar{R}$ and $\bar{E}$ are the means of these respective variables. The values of these net effects were -5.4E-04 for beef and -5.5E-03 for seafood. The average effect of a typical paragraph would be the net effect divided by $\bar{R}$, which is -2.5E-4 for beef and -3.9E-03 for seafood. In other words, on average, a single food safety paragraph about beef was associated with a 0.025-percent fall in beef consumption for the year in question, and a paragraph about seafood was associated with a 0.392-percent fall in seafood consumption, all else being equal.