The Economic Effects of Fish Kills and a Seafood Inspection Program in North Carolina

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Abstract

The discovery of Pfiesteria Piscicida as one cause of fish kills in North Carolina raised consumer concerns about seafood safety and sent shock waves through the seafood industry in the Mid-Atlantic region. This paper assesses the economic costs of fish kills and the benefits of a seafood inspection program in North Carolina using revealed and contingent seafood demand data. We find that seafood is a normal good and seafood demand is price inelastic. Average consumption of seafood increases with seafood inspection programs. A fish kill in the eastern North Carolina region reduces total expenditure on seafood between 29.29 percent and 31.99 percent per month.

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INTRODUCTION

Seafood remains one of the most complex sectors in the food industry, with its subjection to global politics, population dynamics, economics and weather – each of which can upset the delicate balance of supply and demand. Concern about seafood safety, especially fish kills, has become an important social, political and economic issue in North Carolina.

The discovery of Pfiesteria Piscicida as one cause of fish kills in North Carolina (Burkholder, et al., 1992) raised consumer concerns about seafood safety and sent shock waves through the seafood industry in the Mid-Atlantic region. Lipton (1998) conducted a study of the economic impact of Pfiesteria-related fish kills on the seafood industry's sales and on recreational fishing in Maryland. He found that 360 seafood firms in Maryland lost about $43 million because of public concern about seafood safety when Pfiesteria Piscicida was identified in Chesapeake Bay tributaries. Diaby (1996) estimated the economic impact of the two week Neuse River closure to commercial fishing due to Pfiesteria-related fish kills. About twenty-five seafood employees lost two weeks of work.

The belief that seafood may be unsafe could obviously be a barrier to seafood consumption. Griffith (1999) suggests that environmentalists have exaggerated Pfiesteria as a public health risk symbol. He argues that Pfiesteria is not a serious threat to public health based on scientific evidence. However, this claim is disputed by Burkholder and Glasgow Jr. (1999) who argue that there is increasing medical evidence that Pfiesteria can seriously affect human health.

According to Wessells, Kline and Anderson, (1996) consumers perceive that there are risks associated with the consumption of seafood, which have negative implications for consumer demand for seafood. Several other studies suggest that many consumers continue to perceive the seafood supply as somewhat unsafe (Anderson and Morrissey, 1991; Lin et al., 1991; and Lin et al., 1993). Efforts to provide safety assurance to consumers have focused on provision of government inspection programs. Both consumer groups and the seafood industry have called these programs inadequate (Wessells and Anderson, 1995).

A considerable amount of research has been done to assess the biological, ecological and environmental effects of Pfiesteria and other harmful algal blooms (Burkholder et al., 1999; Paerl et al., 1998). Very little work has been done with respect to the economic effects of Pfiesteria outbreaks. In this paper, the assessment of the economic costs of fish kills and the benefits of a seafood inspection program in North Carolina will be conducted using revealed and contingent seafood demand data.

Revealed behavior questions are used to gather information from survey respondents on actual seafood transactions carried out by individuals. Revealed behavior information can then be used as a baseline for introducing hypothetical, or contingent scenarios, to respondents and measuring the possible change in economic behavior. In this paper I will review some related studies and a model will be developed to estimate the demand for seafood. Benefits and costs in the seafood market and the economic impact with regards to changes in expenditure will be measured.

LITERATURE REVIEW

A wide range of models and theories, as well as different approaches, have been employed by many researchers to determine the benefits of seafood consumption and economic impacts of seafood safety. Bergstrom, et al., (1996), in a methodologically related study, measured the effects of alternative aquatic plant management strategies on recreational expenditures and regional economic activity. They used contingent behavior data to estimate the standard individual travel cost method demand function of the planned number of trips to a recreational site on Lake Guntersville. Furthermore, they used the demand model to estimate the changes in the economic impacts of recreation with changes in the scenarios (i.e., different management alternatives).

For the economic impact analysis, they used total expenditure defined as the product of total visits and expenditure per visit to determine the economic impacts from recreational trips. Bergstrom, et al., (1996) found that the greatest economic impacts are from two management alternatives, which results in about $160 million worth of total gross output to the eleven county local region surrounding the lake. Management alternatives A and B are to reduce aquatic plant coverage to approximately 30 percent and 20 percent of the lake respectively.

Combining contingent behavior data with multiple scenarios involves multiple responses for each individual resulting in panel data. Bergstrom, et al., (1996) used a regression model without accounting for the panel data to estimate the travel cost method demand function. This is not efficient since individual responses may be correlated due to unobservable differences in taste, which cannot be accounted for by the standard regression model.

In another methodologically related study, Rosenberger and Loomis (1999) used revealed and contingent behavior data to estimate the value of ranch open space to tourists. They used a panel data model, the random effects Poisson, to estimate the value of ranchland in a resort town in the Rocky Mountains through a travel cost demand model. They combine information on data from actual trips with contingent behavior data on intended current visitation if the resource were converted to urban and resort uses.

According to Rosenberger and Loomis (1999), the gain or loss in consumer surplus derived from a visit to the study area attributable to the resource would be the value of the ranch open space to tourists. They found that 25 percent of the sample would reduce visitation and 23 percent would increase visitation if ranch open space were converted to urban and resort uses. They further estimated the accrued benefit of tourists as consumer surplus. The average consumer surplus per group-trip was $1,132 with existing ranch open space. Finally, they found that there is no net effect from not converting the existing ranchland to urban and resort development uses.

Wessells and Anderson (1995) in their study of the consumer willingness to pay for seafood safety assurance used the contingent valuation method to obtain information concerning willingness to pay. Contingent valuation uses survey questions to elicit individual valuation of non-market goods. They tested the hypothesis that consumers are able to discern among seafood safety assurances, rank their preferences and assign values to alternatives. They found consumers have strong preferences for alternative types of seafood safety assurances and are willing to pay a premium for seafood with these assurances.

Lin and Milon (1995) used the contingent valuation method to measure willingness to pay for health risk reductions in shellfish products. They tested for a positive relationship between the amount a respondent says he would be willing to pay for a risk reduction and the magnitude of the reduction. They also looked at the relationship between valuation and the framing of risk information. They found that the reported valuation amount was insensitive to the risk information format. Another important finding was that willingness to pay was influenced by personal experiences with the risk.

Huang, Haab and Whitehead (2000) examine the impact of perceived absolute and relative risks on consumption of goods with substitutes and complements. They used the combination of revealed and contingent behavior data from a seafood consumption study to trace out demand changes in response to absolute and relative risk reductions. Combining the data can improve the efficiency of benefit estimation and also allows a possible test of the consistency of the two types of data.

They developed an analytical model and examine the behavior of various interaction assumptions between own and cross risks on the demand function. Risk reductions are measured quantitatively as a difference in the number of meals that would result in an illness. The results of their study show how multiple risks enter demand in a nonlinear way, which suggests the importance of relative risks on demand. Another important finding is they were able to integrate panel data analysis into their empirical model to account for individual heterogeneity, response correlation and potential structural changes in demand across different scenarios. They also showed that seafood consumption is affected by the perceived absolute risk and by the relative risk to poultry, which confirms that individuals react to the multiple risks in a nonlinear way as they predicted with their analytical model.

There are some potential problems in applying contingent valuation to food safety because of the cognitive process involved (i.e., it is not clear how respondents answer these difficult valuation questions). Respondents may not understand the way the question is framed and ascertaining the perceived risk is a problem. The revealed behavior questions used in this paper can avoid this problem. The contingent behavior method asks questions that may be more familiar to respondents. Fish kills are used as the information to imply that there is a risk change associated with seafood consumption. Instead of asking respondents how much they would be willing to pay for a specific, but abstract, risk change, we ask for changes in the number of meals they would eat with a fish kill. Respondents have more experience with eating seafood meals and reacting to fish kills, and may be able to better answer this question.

DEMAND THEORY

The analysis in this paper is based on the standard economic theory of consumer behavior. A seafood consumer's utility function can be written as

$$U = f(Q, q, Z)$$

where Q is seafood meals consumed, q is the quality of seafood meals and Z is a composite good representing all other goods. Following Henderson and Quandt (1980), we assume the function $f(Q, q, Z)$ is continuous and regular strictly quasi-concave with continuous first- and second-order partial derivatives.

The rational seafood consumer would want to achieve the highest level of satisfaction by maximizing his utility function subject to a budget constraint. The consumer's budget constraint is given as:

$$Y = P_Q Q + P_z Z$$

where Y is income, P_Q is the price of a seafood meal, and P_Z is the price of the composite good which is assumed to equal one ($P_Z = 1$).

Using the Lagrangian method for constrained optimization the consumer's maximization problem becomes:

$$L = f(Q,q,Z) + \lambda(Y - P_Q Q - Z) \text{ ,}$$

The first-order conditions for maximization consist of the following equations:

$$\frac{\partial L}{\partial Q} = \frac{\partial f(Q,q,Z)}{\partial Q} - \lambda P_Q = 0$$

$$\frac{\partial L}{\partial Z} = \frac{\partial f(Q,q,Z)}{\partial Z} - \lambda = 0$$

$$\frac{\partial L}{\partial q} = \frac{\partial f(Q,q,Z)}{\partial q} = 0$$

$$\frac{\partial L}{\partial \lambda} = Y - P_x Q - Z = 0 \text{ ,}$$

It is well known that the ordinary demand function for seafood can be obtained by solving the system of four first-order equations for Q (Henderson and Quandt, 1980).

$$Q^* = f(P_Q, q, Y)$$

The ordinary demand function gives the quantity of seafood meals the seafood consumer will buy as a function of the price of the seafood meal, quality, and the consumer's income.

The comparative static properties of demand are as follows. The law of demand states that:

$$\frac{\partial Q^*}{\partial P_Q} < 0$$

Thus, quantity demanded moves inversely with the price change, all other things being equal. Also,

$$\frac{\partial Q^*}{\partial q} > 0$$

That is, holding the price of seafood and income constant, quantity demanded would increase with seafood quality. Finally, it is assumed that either

$$\frac{\partial Q^*}{\partial Y} > 0 \text{ or } \frac{\partial Q^*}{\partial Y} < 0$$

If seafood is a normal (inferior) good quantity demanded will increase (decrease) with increases in income.

The consumer surplus is the area beneath the demand function and above the price (see figure 1):

$$CS = \int_{P_0}^{P_c} Q^*(\cdot)dp$$

where P_c is the halt price (i.e., the price that forces Q^* to go to zero) and P_0 is the current price of a seafood meal. The consumer surplus per meal is consumer surplus divided by seafood meals consumed, CS/Q.

With an improvement in the quality of seafood meals from q to q_u, the demand function for seafood consumption would shift to the right. The benefit of the quality improvement can be measured as the change in consumer surplus, which would be the area between two demand curves above P_0, which is given by (see figure 2):

$$\Delta CS = \int_{P_0}^{P_u} Q^*(P_x, q_u, Y)dp - \int_{P_0}^{P_c} Q^*(P_x, q, Y)dp$$

where P_u is the halt price associated with q_u.

Likewise, a decrease in the quality of seafood meals from q to q_m would cause the demand function to shift to the left. The loss due to the quality change can once again be measured as the change in consumer surplus, which would be the area between two demand curves above P_0, which is given by (see figure 3):

$$\Delta CS = \int_{P_0}^{P_c} Q^*(P_x, q, Y)dp - \int_{P_0}^{P_m} Q^*(P_x, q_m, Y)dp$$

where P_m is the halt price associated with q_m.

SURVEY AND DATA

To estimate the consumer surplus for seafood, a telephone survey was used to gather data on seafood consumption in Eastern North Carolina, Delaware, Maryland, Virginia, and Washington, D.C. during the year 2000 fish kill season (August – November). The East Carolina University Survey Research Laboratory collected the data. This paper uses only the North Carolina data.

1633 individuals were surveyed for their seafood consumption under varying prices. 1066 respondents provided responses complete enough for analysis. The response rate was 66 percent. 541 respondents completed a follow-up survey that was conducted about one month after of the initial survey. 536 respondents provided responses complete enough for analysis. After deleting bad phone numbers, etc., the response rate was 73 percent of respondents who agreed to the follow-up survey.

The sample is split into those who responded to the follow-up survey and those who did not. Table 1 reports sample characteristics for those who responded to only the first survey (n = 536). 69 percent of the respondents were white and 32 percent of the respondents were males. Each individual surveyed had an average household size of 3 people including one child. The average age of respondents is about 47 years and the average number of years of education is 13.63. The average individual income is about $49,640 per annum.

Table 2 reports sample characteristics of the follow-up survey (n = 536) showing that about 76 percent of the respondents were white and approximately 35 percent of the respondents were males. Each individual surveyed had an average household size of 3 people including one child. The average age of respondents is about 47 years and the average number of years of education is 14.22. The average individual income is about $52,940 per annum.

A T-test shows that the difference in income for the first and follow-up survey respondents is significant at the p = 0.05 level (t =-2.17). Thus the average annual income of respondents in the follow-up survey is $3,300 more than those in the first survey. Education is significantly different at the p = 0.01 level (t = -3.79) suggesting that respondents in the follow-up survey had 0.59 more years of education.

A chi-square test showed that the race difference is significantly different at the p = 0.01 level (c^2 = 6.83[1 *df*]). This shows that there were 7 percent more whites in the follow-up survey than the first survey. Age, household, gender and children are not significantly different for the two groups of respondents.

Information about seafood and fish kills was mailed to individuals who agreed to participate in the follow-up survey. The experimental design of the survey grouped the participants into 6 sub-samples within North Carolina (Table 3). Different information versions were included in the mail out based on the hypothesis that specific information about seafood may affect seafood safety perception and whether the brochure itself matters. There were five sets of information inserts namely, fish kill, seafood inspection program, cover letter, Pfiesteria brochure and counter information.

There were two versions for the fish kill inserts, major and minor fish kill. A major fish kill is described by a hypothetical press release about a kill in the lower Neuse River estimated to affect approximately 300,000 Menhaden, 10,000 Croaker and 5,000 Flounder. A minor fish kill is described by a hypothetical press release with the kill in the lower Neuse River estimated to affect approximately 10,000 Menhaden.

The "counter" information is intended to enforce the notion of the safety of seafood. The information states “YES. In general it IS safe to eat seafood”. It further reports that there has never been a case of illness from eating finfish and shellfish exposed to Pfiesteria and that in general swimming and boating and other recreational activities in costal waters are generally safe. Finally, it has information on what is being done about Pfiesteria by the collaboration of state, federal, and local government and academic institutions. The expectation is that respondents who received this counter information are less likely to worry about seafood safety.

The brochure information discusses Pfiesteria, how it affects fish, whether it is harmful to human health and the safety of seafood. The cause of toxic Pfiesteria outbreaks is discussed as well as who to contact and where to find more information about fish kills.

The hypothetical seafood inspection program proposed a mandatory inspection program by the U.S. Department of Commerce (USDC) instead of the voluntary inspection services of seafood producers and processors (under the authority of the Agricultural Marketing Act of 1964).

Every participant received information on a hypothetical fish kill (major or minor fish kill insert) and information on the hypothetical seafood inspection program. 100 respondents did not receive any brochure and counter information. 200 respondents did not receive any counter information. 200 respondents received all information treatments.

Every individual who participated in the first survey answered a set of four questions about the quantity of seafood they consumed. They were first asked how many seafood meals they ate last month (revealed behavior) and how many they would eat next month (stated behavior). They were asked how many they would eat next month if seafood meal prices went up by one of four different price versions ($1, $3, $5, $7) while all other food prices remain the same. Also they were asked how many seafood meals they would eat next month if price went down by one of four different prices ($1, $2, $3, $4) while all other food prices remain the same. Each person had to answer for one price version.

If they agreed to participate in the follow-up survey, they were asked five additional seafood consumption questions: how much seafood they ate last month (revealed preference), how much they would eat next month, how much they would eat next month after the fish kill, how much they would eat next month after the fish kill and with the seafood inspection program and, finally, how much they would eat next month with the seafood inspection program and a higher price ($1, $3, $5, or $7).

Seafood expenditure is defined to be the product of the price of seafood meals at a restaurant and the quantity of seafood meals at a restaurant plus the product of the price of seafood meals at home and the quantity of seafood meals at home. This is then divided by the sum of quantity of seafood meals at a restaurant and quantity of seafood meals at home to give the average price of a seafood meal for each respondent. Table 4 shows the average consumption of seafood meals for the first set of questions: 4.08 meals was consumed last month when the price was about $10, 4.16 meals for next month if the price was still about $10, 3.27 meals if the price went up to about $14 and 5.09 meals if prices went down to about $8.

The average seafood consumption for the follow-up participants was 3.52 meals for last month if the price was about $10, 3.53 meals for next month if the price is still about $10, 2.73 meals after the fish kill, 3.45 after the fish kill and with the seafood inspection program and finally, 2.71 meals with the seafood inspection program and a seafood price of about $14.

PRELIMINARY TESTS

The quantities of seafood meals in Table 4 are used for the following tests. One test of hypothetical bias in quantity is to determine if people ate what they said they would eat under identical conditions. Comparing equal sample sizes, the difference between how many seafood meals they said they would eat next month (time = 2) and how many seafood meals they ate last month (time = 5) is significant at the p = 0.01 level (t=-3.12). This suggests that respondents ate 0.66 seafood meals less than they said they would eat. Other tests for hypothetical bias compare similar quantities in the surveys. The difference between how many seafood meals they ate last month (time = 1) and how many seafood meals they would eat next month (time = 2) is not statistically different using the T-test. The differences between how many seafood meals they ate last month (time = 5) and how many seafood meals they would eat next month (time = 6) is not significant using the T-test.

A test of demand theory showed a significant difference in seafood meals between how many seafood meals they would eat next month (time = 2) and how many seafood meals they would eat if the price increased (time = 3) at the p = 0.01 level (t=-4.98). This suggests that respondents would eat 0.98 less meals if price increased. Another test of demand theory showed a significant difference between how many seafood meals respondents would eat next month (time = 2) and how many seafood meals they would eat if the price decreased (time = 4) at the p = 0.01 level (t=4.78). This suggests that they would eat 0.93 more meals if price decreased.

The test of the effect of a fish kill on quantity shows that there is a significant difference between how many seafood meals respondents would eat next month (time = 6) and how many seafood meals they would eat if there is a fish kill (time = 7) at the p = 0.01 level (t=-4.10). This suggests that they would eat 0.8 meals less if there is a fish kill.

The test for the effects of a fish kill with a seafood inspection program on quantity showed a significant difference between how many seafood meals respondents would eat if there is a fish kill (time = 7) and how many seafood meals they would eat if there is a fish kill and seafood inspection program (time = 8) at the p = 0.01 level (t=3.66). This suggests that consumers would eat 0.72 more meals with the seafood inspection program when there is a fish kill.

Another test of demand theory is for the effect of increased price on quantity when there is a seafood inspection program. The test showed a significant difference between how many seafood meals respondents would eat if there is a fish kill and seafood inspection program (time = 8) and how many seafood meals they would eat with the same scenario but the price of seafood is increased (time = 9) at the p = 0.01 level (t=-3.91). This suggests that consumers would eat 0.74 less seafood meals.

Finally, I test to see if there are differences in the quantity of seafood meals in the initial and follow-up survey by revealed and stated preference responses. This test showed a significant decrease of 0.53 in meals when comparing how many seafood meals they ate last month for the first survey (time = 1) and how many seafood meals they ate last month for the follow-up survey (time = 5) at the p = 0.01 level (t=-2.85). There is also a significant decrease of 0.63 meals in how many seafood meals respondents would eat next month for the first survey (time = 2) and how many seafood meals respondents would eat next month for the follow-up survey (time = 6) at the p = 0.01 level (t=-3.03).

EMPIRICAL MODEL

A pooled time-series, cross-section model is used because of the panel nature of the data (Fuller and Battese, 1974). The model accounts for the correlation of multiple responses from heterogeneous individuals. The following models give the demand function for seafood consumption. The Ordinary Least Squares (OLS) model is:

$$Q_i = \alpha + \beta' X_i + e_i$$

where b and X are vectors, i=1,2,...,6802 observations and e_i is the stochastic error term. Q is the dependent variable quantity.

The time-series, cross-section model for the "unbalanced panel" data is:

$$Q_{it} = a + b'X_{it} + e_{it}$$

where $e_{it} = m_i + e_{it}$, i=1,2,...,1066 respondents and t=1,2,...,9 observations for each respondent, m_i is the individual effect and e_{it} is the stochastic error term. The panel data is "unbalanced" because different respondents have different number of observations in the sample. The OLS demand function does not take into account the multiple observations per respondent. With OLS there would be correlation between the error terms across respondents. The time-series, cross-sectional regression model takes into account multiple observations per respondent with the individual effect, m_i. This model is more efficient than the OLS model.

The variables Stated preference, Price of seafood meals, Major fish kill, Minor fish kill, Pfiesteria brochure, Counter information, Seafood Inspection program, dummy for Very likely not to be sick, Income, Male (dummy variable for gender), white (dummy variable for race), Age, and Education are elements of the X vector.

Stated preference is equal to one if the observation is stated preference and zero if revealed preference. Minor is equal to one if there is a minor fish kill and zero otherwise. Major is equal to one if there is a major fish kill and zero otherwise. Pfiesteria brochure is equal to one if the individual received the Pfiesteria brochure and zero otherwise. Counter is equal to one if the individual received the counter information and zero otherwise. Seafood inspection equals one if there is a seafood inspection program and zero otherwise. Very likely not to be sick is equal to one if the respondent thinks their chances of getting sick from eating seafood meals is not likely at all and zero if the respondent thinks their chances of getting sick from eating seafood meals are very likely, somewhat likely and somewhat not likely. White is equal to one if white and zero otherwise. Education is the highest grade completed in school. Annual household income is measured as the midpoint of the income interval.

To test demand theory we include the price and income variables. As discussed in the demand theory section, the coefficient on the price of seafood is expected to be negative. The coefficient of income is expected to be positive (negative) if seafood is a normal (inferior) good. Male, white, age and education are included in the regression as proxies for tastes and preferences. Major fish kill, Minor fish kill and the Seafood inspection program are controls for quality. The coefficient on Major and Minor fish kill, are expected to be negative since seafood consumers would think seafood is unsafe when there is a fish kill and therefore eat less seafood meals.

The coefficient on Seafood inspection program is expected to be positive because seafood consumers would consider seafood meals safe with the inspection program. Counter and Pfiesteria brochure information are controls for information effects. These coefficients are expected to be positive because the information included assurances of seafood safety. Stated preference is included in the regression to test for hypothetical bias.

As discussed in the theory section, the area beneath the demand function and above the implicit price is the consumer surplus. Consumer surplus can be computed using the estimated coefficients from the regression model

$$Q = \hat{a} + \hat{b}_p X_p + \sum_{j=1}^{m} \hat{g}_j X_j$$

where Q is the seafood meals consumed, $\hat{b}_p$ is the estimated coefficient of the price variable X_p and $\hat{g}_j$ is the estimated coefficient for the independent variable X_j.

The consumer surplus (CS) for the linear functional form is (Bockstael and Strand, 1987):

$$CS = \frac{-Q^2}{2\hat{b}_p}$$

$$CS/Q = \frac{-Q}{2\hat{b}_p}$$

The effect of a change in an independent variable on consumer surplus is:

$$\frac{\partial CS}{\partial X_j} = \frac{-\hat{g}_j Q}{\hat{b}_p}$$

Since the linear demand model, may be overly restrictive we also consider the semi-log and log-log models. The semi-log and the log-log models guarantees that the expected quantity demanded for seafood will be positive. The consumer surplus (CS) for the semi-log functional form is given as (Bockstael and Strand, 1987):

$$CS = \frac{-Q}{\hat{b}_p}$$

$$CS/Q = -\frac{1}{\hat{b}_p}$$

$$\frac{\partial CS}{\partial X_i} = \frac{-\hat{g}Q}{\hat{b}_p}$$

The consumer surplus (CS) for the log-log functional form if (Graham-Tomasi, Adamowicz and Fletcher, 1990) $\hat{b}_p > -1$:

$$CS = \frac{1}{\hat{b}_p + 1} \cdot (Max(\hat{P})Min(Q) - PQ)$$

$$\frac{CS}{Q} = (\frac{1}{\hat{b}_p + 1} \cdot (Max(\hat{P})Min(Q) - PQ))/Q$$

The effect of a change in an independent variable on consumer surplus is:

$$\frac{\partial CS}{\partial X_j} = \frac{1}{\hat{b}_p + 1}((-\frac{\hat{g}_j}{\hat{b}_p} \cdot \tilde{P}) - (\hat{g}_j \cdot P \cdot Q))$$

where $\tilde{P}$ is the halt price.

The price and income elasticity of the demand function, e_P and e_Y respectively can be calculated using the estimated coefficients from the cross-section, time-series regression model. For the linear demand model these are:

$$e_p = \hat{b}_p \cdot \frac{P}{Q}$$

$$e_Y = \hat{b}_Y \cdot \frac{Y}{Q}$$

For the semi-log demand model these are:

$$e_p = \hat{b}_p \cdot P$$

$$e_Y = \hat{b}_Y \cdot Y$$

For the log-log demand model these are:

$$e_p = \hat{b}_p$$

$$e_Y = \hat{b}_Y$$

where P is the average price of a seafood meal, Q is the average quantity of seafood meals consumed, Y is the average income of the seafood consumer, $\hat{b}_p$ is the estimated coefficient of the price variable and $\hat{b}_Y$ is the estimated coefficient of the income variable.

RESULTS

In this section, I present the cross-section, time-series seafood demand models. The OLS results are presented for comparison purposes.

Linear model

Table 5 shows there is a significant relationship between the Quantity variable and the variables for Price, Major fish kill, Minor fish kill, Stated preference, Pfiesteria brochure, Seafood inspection program, Income and gender dummy Male at the one-percent significance level. Also, at the five percent significance level, there is a significant and positive relationship between the dependent variable and the variables years of Education and Very likely not to be sick. White is also significant and negatively related to Quantity at the five percent significance level. Finally, at the ten percent significance level, there is a significant relationship between Quantity and the independent variable Age.

The negative slope for price suggests that with each $1 increase in price we can expect the average quantity of seafood consumption to decrease by 0.21 meals each month. With each $1000 increase in income we can expect the average quantity of seafood consumption to increase by .024 meals. Furthermore, with the seafood inspection program, the quantity of seafood consumed is 0.73 meals more than when there is no seafood inspection program.

The negative slope coefficient of Major fish kill suggests that seafood consumption decreases by 1.05 meals with a Major fish kill. Similarly, the quantity of seafood consumed decreases by 1.08 meals when there is a Minor fish kill. Seafood consumers who received the Pfiesteria brochure would eat 0.5 meals less than people who did not receive the Pfiesteria brochure. Male seafood consumers eat 0.70 seafood meals more than female consumers. With each added year of education, the average quantity of seafood consumed would increase by 0.10 meals. Whites eat 0.53 seafood meals less than non-whites. The coefficient (0.199) on stated preference suggests a positive hypothetical bias. Thus seafood respondents said they would eat more seafood than they actually did. Lastly, the consumption of seafood consumers who think that they are very likely not to get sick from eating seafood is 0.16 meals higher. With each year increase in age, we expect the average quantity of seafood consumed to increase by 0.01 meals.

Semi–log model

Table 6 shows that there is a significant inverse relationship between quantity and the independent variables for the Price, Major fish kill, Minor fish kill, Pfiesteria brochure and Counter information at the one-percent significance level. Furthermore, the Seafood inspection program, dummy for Very likely not to be sick, Income and gender dummy Male are positively related to the quantity of seafood meals at the one-percent significance level. At the five-percent significance level, there is a positive and significant relationship between quantity and the independent variables Age and Education. White and Stated preference are not significant.

The negative slope for price suggests that with each $1 increase in price we can expect the quantity of seafood meals consumed to decrease by about 5 percent each month. Also, Table 6 suggests that with each $1000 increase in income we can expect the quantity of seafood meal consumption to increase by 0.4 percent.

With the Seafood inspection program, the quantity of seafood meals consumed is 24 percent more than the quantity consumed without the Seafood inspection program if everything else is held constant. The negative slope coefficient of the Major fish kill suggests that the quantity of seafood meals consumed if there is a Major fish kill would decrease by about 25 percent. Similarly, with each Minor fish kill we can expect the quantity of seafood meals consumed to decrease by about 27 percent. Seafood meal consumption increases by about 6 percent if consumers perceive that they are Very likely not to get sick from eating seafood meals.

If the seafood consumer had information on Pfiesteria, they would eat about 6 percent less seafood meals than if they did not have information on Pfiesteria. If the seafood consumer had Counter information, they would eat about 7 percent less seafood meals than if they did not have any counter information. Male seafood consumers eat about 15 percent more meals than female seafood consumers.

Finally, with each year increase in Age, we can expect the quantity of the seafood meals consumed to increase by 0.3 percent. With each added year in Education, we can expect the seafood meals of the consumer to increase by about 2 percent.

Double log model

Table 7 shows the estimated coefficients for the time-series, cross-sectional log-log demand functional form. The independent variables Price, Major fish kill, Minor fish kill and Counter information are significant and negatively related to the quantity of seafood meals at the one-percent significance level. Also, the Seafood inspection program, Very likely not to be sick, Income, Male, Age and Education variables are significant and positively related to the quantity of seafood at the one-percent significance level. The effect of the Pfiesteria brochure is significant and negatively related to the quantity at the five percent significance level.

The coefficient on Price is the estimated elasticity of quantity with respect to Price. A one percent increase in Price increases quantity of seafood consumed by 0.39 percent. Also, the coefficient on Income is the estimated elasticity of quantity with respect to Income. A one percent increase in Income increases quantity of seafood consumed by 0.14 percent. The negative slope coefficient of the Major fish kill suggests that the quantity of seafood consumed if there is a Major fish kill would decrease by about 24 percent. Similarly, a Minor fish kill would decrease seafood consumption by about 26 percent.

The quantity of seafood meals consumed by seafood consumers who received the brochure information would decrease by about 4 percent. The quantity of seafood meals consumed by seafood consumers who received the Counter information would decrease by about 8 percent. Additionally, seafood consumers who think they are Very likely not to be sick from eating seafood meals would increase their consumption by about 6 percent. With a Seafood inspection program, the quantity of seafood meals consumed would increase by about 21 percent, while Male seafood consumers would eat about 14 percent more meals than female seafood consumers. Finally, with each year of Education, the seafood meals consumed would increase by about 2 percent, whereas, with each year increase in Age, seafood meals consumed would increase by about 0.4 percent.

COMPARISON OF MODELS

There are only a few differences in the significance levels across models. Counter information is not significant in the linear demand function but it is significant for the semi-log and log-log functional form of the demand function. Stated preference is not significant for the semi-log and log-log functional form of the demand function but it is significant for the linear functional demand function. More differences are found when comparing elasticity and consumer surplus estimates. All the models have the right signs according to theory.

Elasticities

Table 8 shows the elasticities for the different models. For the linear functional form, the price elasticity of demand for seafood is 0.59, so if price changes by 1 percent, seafood meals consumed would change by 0.59 percent. Income elasticity for seafood is 0.31. Hence, if the income of the seafood consumer changes by 1 percent, the seafood meals consumed would change by 0.31 percent.

For the semi-log functional form, the price elasticity of demand for seafood is 0.52, so if price changes by 1 percent, seafood meals consumed would change by 0.52 percent. Income elasticity for seafood is 0.20. Hence, if the income of the seafood consumer changes by 1 percent, the seafood meals consumed would change by 0.20 percent.

For the log-log functional form, the price elasticity of demand for seafood is 0.39, so if price changes by 1 percent, seafood meals consumed would change by 0.39 percent. Income elasticity for seafood is 0.14. Hence, if the income of the seafood consumer changes by 1 percent, the seafood meals consumed would change by 0.14 percent.

The results from the elasticities suggest that seafood demand is price inelastic and seafood is a normal good. The linear model has the highest estimates for price and income elasticities. The difference between the estimated price and income elasticities for the linear and semi-log functional form is 0.07 and 0.1 respectively. Also, the difference between the estimated price and income elasticities for the linear and log-log functional form is 0.2 and 0.17 respectively.

Consumer Surplus

From Table 9 and using the linear functional form, the monthly consumer surplus per seafood consumer is $34.38 and consumer surplus per seafood meal is $9.05. The change in consumer surplus with a major fish kill is -$19.05 month and the change in consumer surplus with a minor fish kill is -$19.60 per month. The monthly change in consumer surplus with a seafood inspection program is $13.14.

For the semi-log functional form, the monthly consumer surplus per seafood consumer is $77.55 and consumer surplus per seafood meal is $20.41. The change in consumer surplus with a major fish kill is -$22.49 per month and the change in consumer surplus with a minor fish kill is -$24.82 month. The monthly change in consumer surplus with a seafood inspection program is $16.83.

Finally, estimates for consumer surplus using the log-log functional form indicates that the monthly consumer surplus per seafood consumer is $157.36 and consumer surplus per seafood meal is $41.63. The change in consumer surplus with a major fish kill is -$140.38 per month and the change in consumer surplus with a minor fish kill is -$151.41 month. The monthly change in consumer surplus with a seafood inspection program is $96.26.

The double log model has the highest estimates for consumer surplus followed by the semi-log model and then the linear model. The differences between the monthly consumer surplus per seafood consumer for the linear model and that of the semi-log and double log model are $43.17 and $122.98 respectively. The differences between the consumer surplus per seafood meals for the linear model and that of the semi-log and double log model are $11.36 and $32.58 respectively.

Also, the differences between the change in consumer surplus with a major fish kill per month for the linear model and that of the semi-log and double log model are $3.44 and $121.33 respectively. The differences between the change in consumer surplus with a minor fish kill per month for the linear model and that of the semi-log and double log model are $5.22 and $131.81 respectively. Finally, the differences between the monthly change in consumer surplus with a seafood inspection program for the linear model and that of the semi-log and double log model are $3.69 and $77.99 respectively.

POLICY IMPLICATIONS

Economic Impacts

Using a simple approach to estimate the economic impact by assuming there is no multiplier effect, I use the demand model to provide an illustration of the economic effects of a fish kill and seafood inspection program. It is estimated that the population for the eastern North Carolina counties included in the sample is about 3.07 million. About 60 percent of the population are seafood consumers. Thus, about 1.8 million eastern North Carolina residents eat seafood (July, 1999 estimate, US census Bureau). The average price of seafood is $10.63. The average quantity of seafood meals consumed each month is 3.78. The total number of seafood meals consumed in eastern North Carolina is about 6.8 million and the total expenditure on seafood is about $72.33 million each month.

Using the semi-log demand model which gives consumer surplus and elasticity estimates that are between the estimates of the linear and double log model, a major fish kill would mean each seafood consumer would eat 29 percent fewer meals per month. Hence, if there is a major fish kill the consequence would be a reduction in expenditure of about $21.19 million per month in the eastern North Carolina region. Similarly, with a minor fish kill each seafood consumer would eat about 32 percent less meals per month. Hence, if there is a minor fish kill the consequence would be a reduction in expenditure of about $23.14 million per month in the eastern North Carolina region.

A seafood inspection program would cause an increase of about 22 percent in seafood meals per consumer per month. Hence, a seafood inspection program would increase expenditure by about $15.69 million per month for the eastern North Carolina region. Therefore, when there is a major and minor fish kill with a seafood inspection program the net effect would be $5.5 million and $7.45 million less in expenditure respectively for the eastern North Carolina region.

Benefits and Costs

Seafood consumers gain utility from eating seafood meals. The value of utility, or benefits to the seafood consumer, is measured as consumer surplus. This is the amount of benefits seafood consumers gain above what they actually pay in expenditures for the seafood meals. Using the semi-log demand model the total benefits (consumer surplus) of seafood meals is $139.59 million each month. The total change in consumer surplus with a major fish kill is -$40.48 million. Similarly, the total change in consumer surplus with a minor fish kill is -$44.68 million. The total change in consumer surplus with a seafood inspection program is $30.29 million. Therefore, when there is a major and minor fish kill with a seafood inspection program the net effect would be $10.19 million and $14.39 million less in consumer surplus for the eastern North Carolina region.

CONCLUSION

The objective of this project is to estimate the demand for seafood and also to estimate the consumer surplus and economic impact of fish kills and the seafood inspection program. The demand models conformed to demand theory. The results of the analysis indicate that seafood is a normal good and seafood demand is price inelastic. Average consumption of seafood increases with seafood inspection programs. Several results were unexpected. For example, the Counter and Pfiesteria brochure information are negatively related to the quantity of seafood meals consumed. These unexpected results could be due to the fact that the seafood respondents started with the idea that seafood was safe and when they read the Counter and Pfiesteria brouchure information decided that seafood was not safe.

Also, I expected the size of the coefficients of a major fish kill to be considerably bigger than that of a minor fish kill. The results show that the sizes of the coefficient are similar for major and minor fish kill across the functional forms. This means that the seafood respondents perceived the negative effect of an approximately 300,000 menhaden, 10,000 croaker and 5,000 flounder fish kills to be the same as an approximately 10,000 menhaden fish kills.

Finally, there is a hypothetical bias in the linear model. The Stated preference variable is statistically significant, but the size of the effect is small. There is no hypothetical bias for the semi-log and double log model. Hence, the results are mixed.

The results, provided in this paper are important inputs for cost benefit analysis, policy and management decision making for the seafood industry. There is a reduction in expenditure of between 29.29 percent and 31.99 percent of the total expenditure on seafood per month when there is a fish kill in the eastern North Carolina region. A seafood inspection program would increase the total expenditure on seafood per month by 21.69 percent. Considering the benefit of a seafood inspection program, if the total cost were more than $30.29 million each month, the seafood inspection program would not be efficient. An environmental policy to avoid a fish kill that would cost more than $45 million would not be efficient.

Future research should consider a more developed model to look at how information on Pfiesteria and Seafood inspection programs affects safety perceptions and perceived health risk of seafood consumers. Research to examine how information on Pfiesteria is associated with the perceived risk of seafood safety and how the perceived risk would affect consumption would be useful. Finally, research using data from a longitudinal survey to get revealed preference data on price and quantity, which can be linked to actual fish kills would be appropriate, but expensive.

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TABLE 1

Demographics of the First Survey sample
(n = 536)

	Mean	Standard Deviation	Minimum	Maximum
Income	49.64	24.96	5.00	100.00
Age	47.12	17.23	18.00	100.00
Education	13.63	2.58	0.00	20.00
Male	0.32	0.47	0.00	1.00
Household	2.68	1.34	1.00	8.00
Children	0.73	1.04	0.00	5.00
White	0.69	0.46	0.00	1.00

TABLE 2

Demographics of the First and Follow-up survey sample
(n = 536)

	Mean	Standard Deviation	Minimum	Maximum
Income	52.94	25.01	5.00	100.00
Age	47.38	16.13	18.00	100.00
Education	14.22	2.55	3.00	20.00
Male	0.35	0.48	0.00	1.00
Household	2.70	1.33	1.00	7.00
Children	0.72	1.06	0.00	5.00
White	0.76	0.42	0.00	1.00

TABLE 3

Experimental Design

Sub Sample	Fish Kill Insert	Seafood Inspection	Cover Letter	Brochure	Counter Information	Expected Sample Size
1	Minor	Yes	Yes	Yes	Yes	200
2	Major	Yes	Yes	Yes	Yes	200
3	Minor	Yes	Yes	Yes	No	200
4	Major	Yes	Yes	Yes	No	200
5	Minor	Yes	Yes	No	No	100
6	Major	Yes	Yes	No	No	100

TABLE 4

Means of seafood consumption and price

TIIME SERIES INDICATOR	**SCENARIO**	**QUANTITY OF SEAFOOD MEALS**	**PRICE**	**Sample size**
1	Revealed preference	4.08 (4.00)	10.14 (4.61)	1065
2	Stated preference [Base Case]	4.16 (4.16)	10.15 (4.59)	1036
3	Stated preference [Price increase]	3.27 (3.95)	14.17 (5.21)	1027
4	Stated preference [Price decrease]	5.09 (4.72)	7.68 (4.67)	1042
5	Revealed preference	3.52 (3.10)	10.01 (4.64)	536
6	Stated preference [Base Case]	3.53 (3.17)	10.03 (4.64)	525
7	Stated preference [Fish kill]	2.73 (3.15)	10.05 (4.64)	512
8	Stated preference [Fish kill and Seafood inspection program]	3.45 (3.20)	10.02 (4.65)	526
9	Stated preference [Fish kill, Seafood inspection program and price increase]	2.71 (2.94)	13.89 (5.17)	524

NOTE: Standard Deviation in parenthesis.

TABLE 5

Seafood Meal Linear Demand Models

Dependent variable = Quantity

Variable	**Coefficient Estimate using OLS (n = 6802, R^2 = 0.07)**	**Coefficient Estimate using Cross-sectional Time Series (n =1066, R^2 = 0.13)**
Intercept	0.766** (0.341)	2.980*** (0.755)
Stated preference	0.177 (0.115)	0.199*** (0.054)
Price	-0.063*** (0.009)	-0.210*** (0.009)
Major fish kill	-1.089*** (0.219)	-1.053*** (0.112)
Minor fish kill	-1.058*** (0.220)	-1.083*** (0.114)
Pfiesteria brochure	-0.348** (0.149)	-0.471*** (0.093)
Counter information	0.004 (0.170)	-0.095 (0.118)
Seafood Inspection program	0.376* (0.205)	0.726*** (0.099)
Very likely not to be sick	0.528*** (0.097)	0.163** (0.081)
Income	0.023*** (0.002)	0.024*** (0.005)
Male	0.528*** (0.096)	0.692*** (0.236)
White	-0.500*** (0.107)	-0.529** (0.259)
Age	0.021*** (0.003)	0.012* (0.007)
Education	0.109*** (0.019)	0.104** (0.048)

Note: Standard errors in parentheses.
******* =Significant at the 0.01 level or better.
****** = Significant at the 0.05 level or better.
***** = Significant at the 0.10 level or better.

TABLE 6

Seafood Meal Semi-Log Demand Models

Dependent variable = Log(Quantity)

Variable	Coefficient Estimate using Semi-log OLS (n = 6802, R^2 = 0.10)	Coefficient Estimate using Semi-Log Cross-sectional Time Series (n =1066, R^2 = 0.20)
Intercept	0.772*** (0.057)	1.271*** (0.127)
Stated preference	-0.005 (0.019)	0.006 (0.011)
Price	-0.014*** (0.002)	-0.049*** (0.002)
Major fish kill	-0.298*** (0.037)	-0.293*** (0.0217)
Minor fish kill	-0.303*** (0.037)	-0.320*** (0.022)
Pfiesteria brochure	-0.051** (0.025)	-0.058*** (0.018)
Counter information	-0.025 (0.028)	-0.077*** (0.023)
Seafood Inspection program	0.146*** (0.034)	0.217*** (0.019)
Very likely not to be sick	0.098*** (0.016)	0.055*** (0.016)
Income	0.004*** (0.0003)	0.004*** (0.001)
Male	0.102*** (0.016)	0.137*** (0.040)
White	-0.055*** (0.018)	-0.044 (0.043)
Age	0.005*** (0.0005)	0.003** (0.001)
Education	0.020*** (0.003)	0.019** (0.008)

Note: Standard errors in parentheses.
******* =Significant at the 0.01 level or better.
****** = Significant at the 0.05 level or better.
***** = Significant at the 0.10 level or better.

TABLE 7

Seafood Meal Double Log Demand Models

Dependent variable = Log(Quantity)

Variable	**Coefficient Estimate using Log-log OLS (n = 6802, R^2 = 0.11)**	**Coefficient Estimate using Log-Log Cross-sectional Time Series (n =1066, R^2 = 0.18)**
Intercept	0.638*** (0.074)	1.243*** (0.150)
Stated preference	-0.012 (0.019)	-0.016 (0.011)
log(Price)	-0.160*** (0.015)	-0.394*** (0.015)
Major fish kill	-0.289*** (0.037)	-0.280*** (0.022)
Minor fish kill	-0.296*** (0.037)	-0.302*** (0.022)
Pfiesteria brochure	-0.057** (0.025)	-0.044** (0.018)
Counter information	-0.020 (0.028)	-0.079*** (0.023)
Seafood Inspection program	0.148*** (0.034)	0.192*** (0.019)
Very likely not to be sick	0.099*** (0.016)	0.058*** (0.016)
Log(Income)	0.133*** (0.014)	0.137*** (0.032)
Male	0.117*** (0.0161)	0.130*** (0.038)
White	-0.057*** (0.018)	-0.042 (0.041)
Age	0.005*** (0.0005)	0.004*** (0.001)
Education	0.023*** (0.003)	0.022*** (0.008)

Note: Standard errors in parentheses.
******* =Significant at the 0.01 level or better.
****** = Significant at the 0.05 level or better.
***** = Significant at the 0.10 level or better.

Table 8

Elasticity Estimates

	Price Elasticity	**Income Elasticity**
Linear model	0.59	0.31
Semi-Log Model	0.52	0.20
Log-Log Model	0.39	0.14

Table 9

Consumer Surplus Estimates in Dollars

	Linear Demand Function	**Semi-Log Demand Function**	**Log -Log Demand Function**
Consumer Surplus (CS)	34.38	77.55	157.36
CS per meal	9.05	20.41	41.63
Change in CS with Major Fish Kill	-19.05	-22.49	-140.38
Change in CS with Minor Fish Kill	-19.60	-24.82	-151.41
Change in CS with Seafood Inspection Program	13.14	16.83	96.26

FIGURE 1

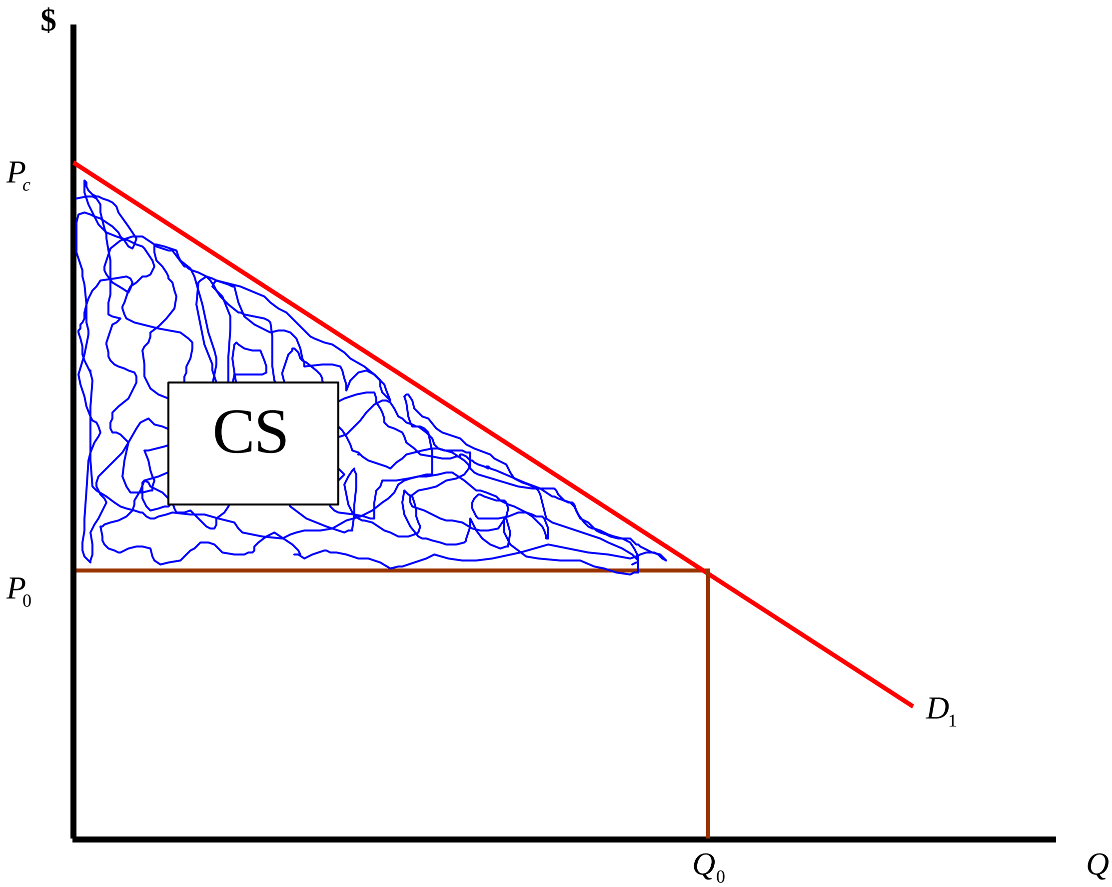

FIGURE 2

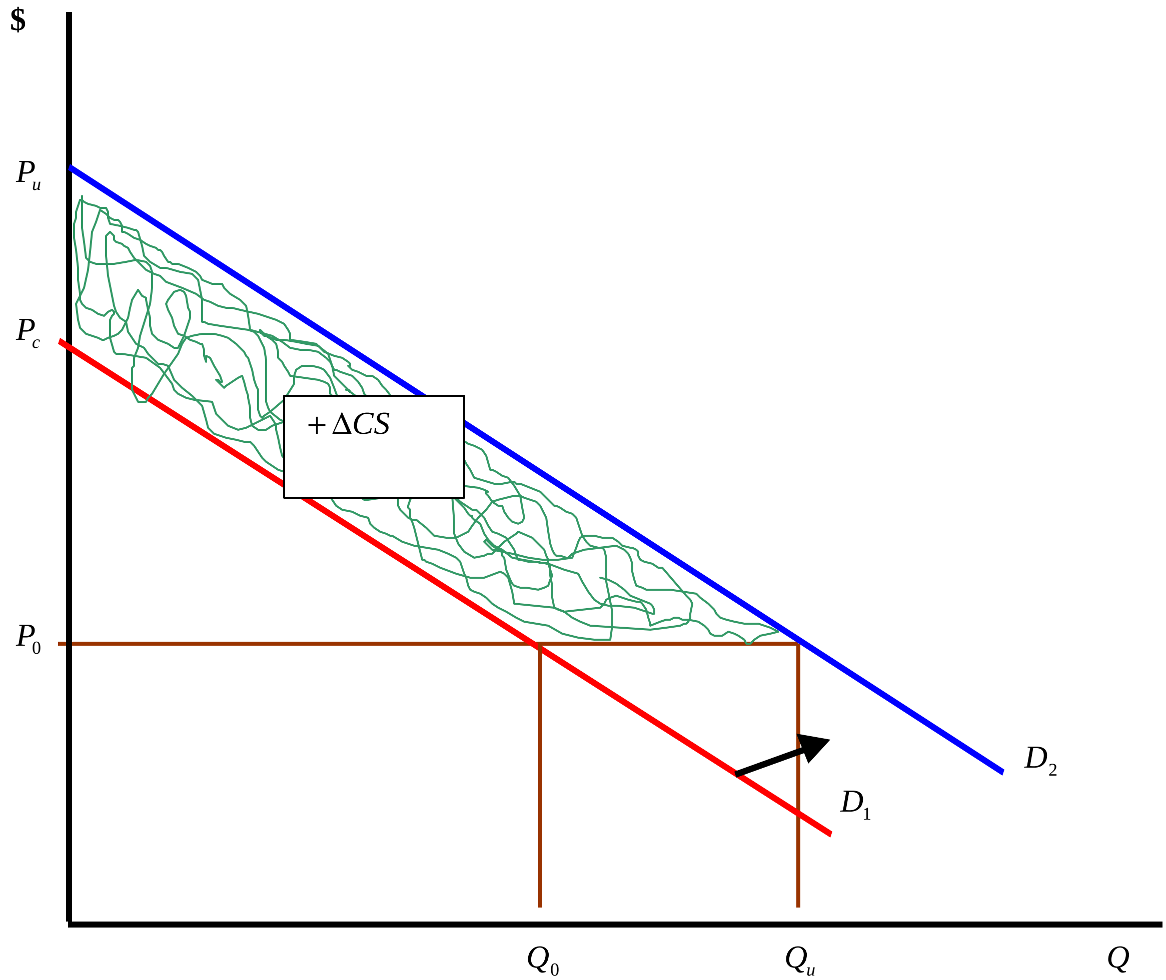

FIGURE 3