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The Economic Value of Situation and Outlook Programs: A Review of Theory and Empirical Evidence

Scott H. Irwin

Public situation and outlook (S&O) programs have a relatively long history. The first formal program is generally thought to be the USDA's Outlook Conference held on April 20, 1923. Since that time, S&O programs have expanded considerably in scope, both at the federal-level under the auspices of the USDA and at the state-level within land-grant colleges of agriculture.

The objectives of public S&O programs probably have not changed a great deal over time. In 1930, H.R. Tolley suggested a purpose statement that, in my view, is still relevant today, "One of the primary objectives of outlook work has been, and probably will continue to be, to obtain and make available to farmers information that will be helpful to them in planning their production programs so as to obtain the greatest returns for their efforts and resources" (p.523).

In recent years, the economic value of public S&O programs is being increasingly questioned. I believe there are two main reasons for the reappraisal of the value of these programs. The first is the growth of private firms that provide relatively low-cost market information and analysis services of the type traditionally provided by public programs.[1] The surge in private activity is related to the rapidly declining cost of gathering, processing, and distributing information. It is argued that public S&O programs can be downsized because private information providers are now available to perform the functions historically provided by public programs (e.g., Just 1983).

The second reason is the intellectual challenge provided by rational expectations theory. Briefly, if producers have rational expectations, then they make optimal use of all available information and do not make systematic forecasting mistakes. Hence, social welfare cannot be increased by providing producers with "better" price and quantity forecasts, as producers already make optimal forecasts.

In this paper, I will explore the recent challenges to S&O programs. In the first part of the paper, theoretical arguments regarding the economic value of S&O programs will be discussed. Three theoretical frameworks will be examined: (1) a cobweb model, (2) a rational expectations model, and (3) a rational expectations model with learning and costly information. In the second part of the paper, the direct empirical evidence on the economic value of S&O programs will be reviewed.

Theory

Cobweb Model

The economic value of S&O information will be considered initially in a cobweb model. This is a useful starting point for two reasons. First, cobweb models are employed in several formal studies in this area (e.g., Smyth 1972, Freebairn 1976). Second, analysis based on cobweb models provides the traditional theoretical justification for S&O programs.

The most basic cobweb model is employed here for ease of exposition. The cobweb model is a slightly modified version of the model considered by Freebairn (1976). Supply and demand functions are assumed to be nonstochastic. Storage is not allowed. Linear demand and supply functions are assumed. Quantity demanded or supplied is assumed to adjust costlessly to the relevant price. Model parameters are assumed to be known by producers. Due to production

[1]One only has to spend a few minutes at a DTN screen to appreciate the point.

lags, supply decisions are assumed to be made at time t-1, while quantity is supplied brought to the market at time t. Hence, producers must form expectations at time t-1 for price at time t. Naive expectations are assumed, so producers expect price at time t to equal the market-clearing price at time t-1. Finally, at each period the predetermined supply is priced such that the market clears.

In mathematical form, the cobweb model is specified as follows,

$$Q_t^s = a + bP^*_t \quad (1)$$

$$Q_t^d = c - dP_t \quad (2)$$

$$P^*_t = P_{t-1} \quad (3)$$

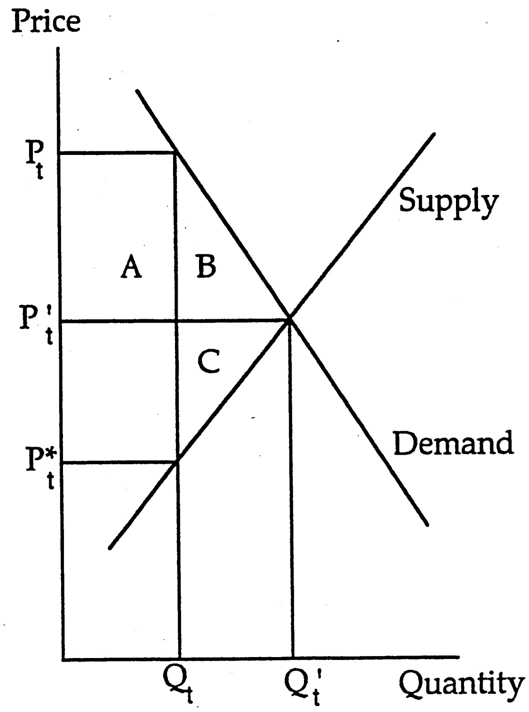
$$Q_t = Q_t^s = Q_t^d \quad (4)$$

where Q_t^s is the quantity supplied, Q_t^d is the quantity demanded, Q_t is realized quantity, P_t is the realized price at time t, P_{t-1} is the realized price at time t-1, and P^*_t is producers' expected price for time t (formed at time t-1). Solution of the model yields the familiar cobweb movement of prices and quantities. Whether the fluctuations are convergent, perfectly regular, or divergent depends on the parameter values of the model.

Following Freebairn (1976), the welfare implications of S&O information will be examined in terms of improvements in the accuracy of price forecasts rather than quantity forecasts. The improvement may be direct, through the provision of more accurate price forecasts, or indirect, through the provision of improved information on prospective supply and demand conditions. Welfare is measured by consumer and producer surplus, which implies the usual caveats regarding the appropriateness of these measures of well-being.

The nonstochastic (or risk-neutral) welfare impacts of improved price forecasting on the part of producers are illustrated in Figure 1. To start, note that if producers have perfect foresight, they expect price P'_t produce quantity Q'_t and the market clears at the intersection of the supply and demand curves. This produces the classic Pareto-optimal outcome where the sum of consumer and producer surplus is maximized. In this example, when producers behave according to the cobweb model, they expect price P^*_t which is less than the perfect foresight price. Producers then supply Q_t and the market clears at price P_t. Compared to the perfect foresight equilibrium, consumer surplus is reduced by area A + B, while producer surplus is reduced by area C - A. Net social loss is the sum of these two areas and equals area B + C. An analogous result is found if producer expectations are greater than the perfect foresight price.

Figure 1. Market Equilibrium Under Alternative Expectation Assumptions



The previous cobweb example indicates that deadweight social loss (area

B + C) can be reduced if producers improve the accuracy of their price forecasts. Freebairn (1976) derives a useful formula for the net social loss in the cobweb model,

$$W = \frac{bd}{2(b+d)} (P^*{}_t - P_t)^2 \qquad (4)$$

where W is the net social loss and b and d are the absolute values of the slopes of the supply and demand functions, respectively. The formula shows that net social loss is proportional to the squared forecast error of producers. Hence, welfare loss is larger in situations where a few large forecast errors are made compared to a situation where many small forecast errors are made. In addition, for a given forecast error, the welfare loss is larger when the absolute value of the slopes of the supply and demand functions is larger. Assuming slopes (again in absolute value) vary directly with time horizon, this implies potential welfare losses are larger, the longer is the time-horizon.

It should be noted that the analysis is based on a nonstochastic (or risk-neutral) cobweb model. Smyth (1972) examines a stochastic cobweb model and finds that S&O forecasts dampen the fluctuations of price over time. Hence, to the extent that reductions in price variance improve social welfare, the analysis based upon a nonstochastic cobweb model generalizes to a stochastic cobweb model.

In sum, the analysis presented in this section provides the traditional theoretical justification for the provision of S&O information to producers. If producers have backward-looking (cobweb) price expectations, they make systematic forecasting errors. This, in turn, results in misallocations of resources. Hence, social welfare can be increased by providing producers with more forward-looking forecasts. It is usually argued that S&O programs provide the improved forecasts.

Rational Expectations Model

As noted in the previous section, the cobweb model assumes producers have naive expectations, which leads to systematic forecasting mistakes. This assumption has come under severe criticism in the last decade. Instead, it is argued that producers have strong incentives to use information optimally when forming expectations.[2]

An alternative assumption is that producers form rational expectations (Muth 1961). In simplest terms, rational expectations imply that producers use all available information when making forecasts and do not make systematic mistakes. More formally, producers' subjective expectations are the same as the "true" underlying economic model. Rational expectations is a logically-appealing assumption regarding producer expectations and has been widely applied to agricultural models in recent years.[3]

Rational expectations can be easily imposed on the model specified in equations (1) through (4). Noting that expectations are assumed to be subjectively certain, the only change is that equation (3) is replaced by:

$$P^*{}_t = P_t \qquad (6)$$

In other words, producers' rational expectation of price at time t is the perfect foresight price. The rational expectations equilibrium is found by solving equations (1), (2), (4), and (6). The solution is simply

[2]It may be said that it is naive to expect producer expectations to be naive!

[3]See Irwin and Thraen (1994) for a thorough review of the concept of rational expectations and its application in agricultural models.

the perfect foresight price and quantity.[4] Any other solution implies systematic forecasting mistakes on the part of producers.

The rational expectation model produces a startling result with respect to the social welfare value of S&O information. Specifically, S&O programs *cannot* improve social welfare in a rational expectations equilibrium. Referring again to Figure 1, the rational expectation equilibrium is given by price P'_t and quantity Q'_t. Since the sum of consumer and producer surplus is maximized in this equilibrium, no further improvement in social welfare is possible. In fact, any resources spent on public S&O programs represent a net social loss.

It should be pointed out that the above analysis is based on a nonstochastic (or risk-neutral) rational expectation model. Goss and Stein (1992) examine a model with stochastic (uncertain) expectations and show that net social loss, while not zero, is minimized under rational expectations. Hence, the analysis of the value of S&O forecasts is also valid when uncertainty is added to the rational expectation model.

Clearly, the rational expectations model provides a strong theoretical challenge to public S&O programs. One response is that producers do not have rational expectations. In my judgment, this is not a compelling argument. Despite mixed empirical evidence, rational expectations is the most logical expectations mechanism available. Other well-known expectations mechanisms (naive, adaptive) imply systematic forecasting mistakes on the part of producers. Therefore, I concur with a number of other authors who argue that the rational expectations model should serve as the theoretical benchmark in economic analysis (e.g., Bray 1985, Newbery and Stiglitz 1981, Goss and Stein 1992).[5]

I believe a better response is to argue that the previous rational expectations model is too stark in that it does not recognize two crucial and related elements of real-world markets. First, the previous rational expectation model requires that producers know the true underlying parameters of the supply and demand functions. The mechanism by which they learn these parameters is not specified. Second, the previous rational expectations model assumes that information is costless. Hence, producers incur no costs as they gather and analyze information in the process of forming expectations. We will see in the next section that relaxing these two assumptions opens the door again to a theoretical justification for the provision of public S&O information.

Rational Expectations Model with Learning and Costly Information

The previous rational expectation model is based on strong assumptions regarding learning and the cost of information. Specifically, learning is instantaneous and information is costless. Incorporating more realistic learning and information assumptions into rational expectation models is extremely complex (e.g., DeCanio 1979, Grossman and Stiglitz 1980, Bray 1983, Bray and Savin 1986). Hence, the analysis in this section will be descriptive only.

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[4]The equilibrium solutions to this simple rational expectations model (equations (1), (2), (4), and (6)) are,

$$P_t = \frac{c - a}{b + d} \qquad Q_t = \frac{ad = bc}{b + d}$$

Note that under subjective certainty of expectations, the rational expectations solutions are the same as the standard neo-classical supply and demand model solutions. This highlights the expectation assumption embedded in the neo-classical model.

[5]There are prominent skeptics regarding this issue (e.g., Pesaran 1987).

First, assume that producers learn the true parameters of the model only with the passage of time and at a positive cost. Then, a rational expectations equilibrium cannot be reached instantaneously. Attention is instead focused on the convergence properties of the model. That is, do market prices and quantities *converge* towards a rational expectation equilibrium? If a model does converge, then two more questions are important: (1) How quickly does the model converge to a rational expectations equilibrium? and (2) What factors affect the speed of convergence to a rational expectations equilibrium?

Figure 1 helps illustrate the issues. Assume producers begin with cobweb expectations, which result in an equilibrium price and quantity of P_t and Q_t, respectively. Next, assume producers realize the cobweb expectation mechanism leads to systematic forecasting mistakes. As a result, producers invest in a learning process with the goal of discovering the true parameters of the model. If producers are successful in learning the true parameters, the rational expectations equilibrium (P'_t and Q'_t) will be achieved.

From a social welfare standpoint, a critical issue is the speed of convergence towards the rational expectation equilibrium. At the initial cobweb equilibrium in Figure 1, net social loss is area B + C. This loss is reduced each period as producers obtain more accurate information regarding model parameters. When producers finally learn the true parameters, net social loss is zero. Total social loss will be the sum of net losses for each period. Hence, all else constant, total social loss will be smaller, the faster that a rational expectations equilibrium is achieved. This analysis suggests that we should be keenly interested in the factors that affect the speed of convergence to a rational expectations equilibrium.

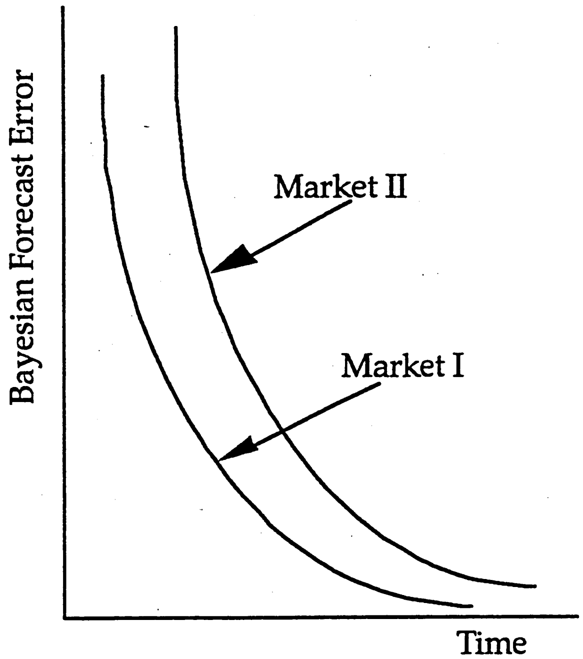
Stein (1992a, 1992b) develops commodity market models that explicitly incorporate learning behavior and costly information. His analysis provides useful insights regarding the factors that impact the speed of convergence towards a rational expectation equilibrium. Stein first assumes that producers only observe past observations on price and other fundamentals. In this case, producers form price expectations via Ordinary Least Squares (OLS) projections of price on the historical fundamentals. This "OLS learning" involves little or no cost and tends to produce cobweb price cycles.

Next, Stein assumes that producers engage in a learning process that is considerably more sophisticated and forward-looking. Here, producers collect information on *prospective* supply and demand conditions and learn model parameters through a Bayesian process. There is a positive cost associated with collecting information, and it is directly related to the heterogeneity of local market conditions and the marginal cost of sampling. A commodity with heterogeneous local markets means that more samples have to be taken to achieve a given level of precision. A commodity market with high marginal costs of sampling means that it is costly to locate and collect information at the margin. Stein shows that the speed of convergence to a rational expectations equilibrium is inversely related to the previous two cost factors.

Figure 2 summarizes Stein's results regarding learning, information costs, and the speed of convergence to a rational expectations equilibrium. The vertical axis, labeled Bayesian forecasting error, shows the difference between producer expectations of price and the "true" rational expectation of price, while the horizontal axis shows time. Speed of convergence for two different markets is presented in Figure 2. Note that the

Bayesian forecast error asymptotically approaches zero in both markets, and hence, producers' expectation of price converges towards the rational expectation in both markets. However, convergence is much faster in Market I than in Market II because market conditions are assumed to be more homogeneous and/or marginal costs of sampling lower in Market I. As a result, producers in Market I learn the true underlying parameters of the model more quickly.

Figure 2. Speed of Convergence to a Rational Expectations Equilibrium



We can now return to the issue of the social welfare value of public S&O programs. Stein's analysis suggests public S&O information will increase social welfare if it increases the speed of convergence to a rational expectation equilibrium. This can be seen most clearly by referring again to Figure 2. Define Market II as a market without public S&O information and Market I as the same market with public S&O information. Then there is a welfare gain (reduction in net social loss) associated with the provision of public S&O information because the speed of convergence to a rational expectations equilibrium is increased.

In my judgment, there are two plausible ways that public S&O programs may increase the speed of convergence to a rational expectations equilibrium. First, the programs help educate producers regarding the structure and parameters of the underlying economic model and prospective economic conditions.[6] In Stein's terms, this means increasing the number of producers that employ Bayesian learning instead of OLS learning. Second, public agencies may be able to collect some information more inexpensively than private firms. The agency may be able to achieve economies of size that a single firm cannot achieve, or the agency may have lower marginal costs of sampling. For example, if producers believe a government agency objectively collects and disseminates information, then producers may be willing to freely diverge information. A private firm seeking the same information for private gain may have to pay a substantial premium to producers in order to obtain the information.

This framework also provides some interesting insights into situations where public S&O information may be more or less valuable. The existence of futures and options markets is one example. Stein argues that the existence of these markets substantially lowers the cost of trading, which allows firms to more readily profit from their private information. This, in turn, speeds convergence to a rational expectation equilibrium. Hence, it can be

[6]This is not an original idea by any means. While in graduate school at Purdue, I was repeatedly reminded (reprimanded?) by Carroll Bottum, a fifty-year veteran of outlook work, that forecasts should only be attention-getters to attract people to outlook meetings, while the real purpose of such meetings was to provide economic education.

hypothesized that S&O programs are less valuable in markets with futures and options trading.

Technological change that lowers the cost of collecting and disseminating information is another example. As a consequence, costs facing private firms may be lowered to the extent that the government's economy of size advantage is eliminated. Enormous improvements in remote sensing, communications, and computer technology have occurred in the last decade. Therefore, it can be hypothesized that public S&O programs are less valuable today than in the past.

To summarize, incorporating learning behavior and costly information into rational expectation models suggests public S&O information may improve social welfare. The improvement is the result of increasing the speed of convergence towards a rational expectations equilibrium.

Information Externalities

Up to this point, the analysis has concentrated on the direct welfare impacts of public S&O information. Private and social values are assumed to be the same. In fact, there are two important externalities that may drive a wedge between the private and social value of information.

The first is a what Hirshleifer and Riley (1992) call the "public good effect." This occurs because trading based on private information may reveal some or all of the information to other market participants. For example, assume a grain firm possesses information regarding a large export sale. If the firm takes a long futures position to take advantage of the information, the act of trading may reveal the firm's information to other market participants. Because of the information leakage, the firm is not able to fully appropriate the returns to the information. In other words, a free-rider problem is created. This tends to cause an under-investment in information-producing activities. In this circumstance, public S&O information may have a high social value.

The second externality is what Hirshleifer and Riley (1992) term "the speculative effect." This externality occurs when the returns to information are largely distributive between uninformed and informed market participants. Consider the case of a group of traders that conducts research in an effort to determine the size of next year's corn crop. Based on their research, each trader takes a position in the grain futures market. When the correct crop size is announced, the futures profits of the correct forecasters will tend to offset the losses of the incorrect forecasters. Assuming the research and trading do not enhance economic efficiency, the research costs of the group as a whole represent a net social loss. This speculative effect tends to lead to an over-investment in information-producing activities. In this case, public S&O programs have a negative social value as they contribute to the over-investment in information.

A general theoretical result is not available regarding the dominance of either the public good or speculative effect. Casual observation suggests both effects are at work in real-world markets. On one hand, uninformed traders clearly do attempt to discover informed traders' information through price movements and knowledge of trading positions. For example, wire services frequently report the trading activity of large futures merchants, commercial firms, and large speculators. On the other hand, there also is a huge investment in information-producing activities in futures markets, which are zero-sum games. This is suggestive of a potential for speculative over-production of information.

In the end, which effect dominates is a matter of judgment. In an important paper, Just (1983) argues that the speculative effect dominates in agricultural markets, particularly those associated with futures trading. My own view is that it is impossible to verify which effect dominates. Hence, I believe the most defensible position is to assume that the effects offset each other or that the net effect is small enough that it can be safely ignored. The following review of empirical studies adopts this viewpoint and therefore concentrates on the direct welfare implications of the evidence.

Empirical Evidence

A search of the literature revealed only four empirical studies that attempt to directly estimate the welfare benefits of public S&O information. The methodology used in the studies is fairly standard. That is, a theoretical structure for a market is proposed, parameter estimates obtained, and then social welfare is estimated under different information or expectation assumptions.

Hayami and Peterson (1972) measure the social welfare of reducing the sampling error of USDA crop and livestock statistics. They assume producer expectations are given by USDA estimates of crop size and livestock production. Based on a simple supply and demand model, estimated elasticities, and baseline data from 1966-68, they report that the net social benefits of reducing the sampling error of USDA crop and livestock statistics substantially exceeds added costs of data collection. For example, Hayami and Peterson estimate that each extra dollar invested in increasing the accuracy of statistics from the 2.5 to 2.0 percent level of error increases net social welfare more than $600.

Freebairn (1976) estimates the social value of commodity price outlook information to Australian agricultural producers. Price forecasts for wool, lamb, wheat, barley, and potatoes are considered. He first assumes that producers have a form of naive expectations (adaptive) and then estimates net social loss based upon the naive expectations, actual prices, and supply and demand elasticities. The sample period for the estimation is 1st quarter 1963 to 3rd quarter 1972.

Next, Freebairn assumes that producers use as expectations the price forecasts supplied by the Australian Bureau of Agricultural of Economics (BAE). Net social losses under the BAE expectations are then compared to the net social losses under naive expectations. In all cases, net social loss is reduced by the use of BAE outlook price forecasts. However, the reductions are less than 1 percent of the gross value of commodity production, indicating rather modest social gains from improving the accuracy of producer price forecasts.

Bradford and Kelejian (1978) analyze the social value of improving the accuracy of USDA wheat crop forecasts. They specify a model where market participants have rational expectations, but the only source of information on potential crop size is an information agency (the USDA). Market participants are assumed to apply a Bayesian updating procedure to the crop forecasts. Model parameters are estimated using data from 1955 -1972. Bradford and Kelejian report a point estimate of the net social loss of less than perfect wheat crop forecasts of $64 million (1975 dollars). Hence, their empirical results indicate substantial benefits to improving the accuracy of USDA wheat crop forecasts.

Antonovitz and Roe (1984) analyze the social value of improved price forecasts to U.S. fed cattle producers. They first assume that producers form expectations based on an ARIMA model of past fed cattle prices. Then, Antonovitz and Roe use a two-equation econometric model to generate rational expectations forecasts. These forecasts are assumed to be provided by an information agency such as the USDA. The ARIMA and econometric models are estimated over the 1970-1980 sample period.

Antonovitz and Roe then calculate the improvement in social welfare that results from the adoption of the rational expectation forecasts by producers. They report that the mean social welfare value of the rational expectation forecasts is $13.3 million per bimonth, or $78 million per year. The results imply substantial social benefits associated with the adoption of rational outlook forecasts.

As a group, these studies seem to provide overwhelming evidence of the social value of public S&O information. However, the social benefits reported in these studies are almost surely overstated. Consider first the studies by Hayami and Peterson and Bradford and Kelejian. In both of these studies, market participants are not allowed to engage in private information-producing activities. With rational expectations, participants have strong incentives to estimate crop size and livestock production based on their private information. Government forecasts will improve social welfare only to the extent that the forecasts contain information not already known by market participants.[7] Accounting for private forecasts should substantially reduce the estimated benefits of improving the accuracy of government forecasts.

Next, consider the studies by Freebairn and Antonovitz and Roe. In both studies, producers are assumed to have some form of naive rather than rational price expectations. It is, therefore, not surprising that adoption of rational outlook forecasts by producers leads to substantial gains in social welfare. However, as argued earlier in this paper, it is questionable to assume that producers do not have rational expectations. Outlook price forecasts should be compared to the rational price expectations of producers. Such a comparison would likely show substantially fewer social benefits associated with the adoption of outlook price forecasts.

Summary and Concluding Comments

In recent years, the economic value of public S&O programs is being increasingly questioned, apparently for two main reasons: (1) the growth of private firms that provide relatively low-cost market information and analysis services of the type traditionally provided by public programs and (2) the intellectual challenge provided by rational expectations theory. Theoretical arguments regarding the social value of S&O programs were considered in three theoretical models: (1) a cobweb model, (2) a rational expectations model, and (3) a rational expectations model with learning and costly information.

The cobweb model indicates that deadweight social loss may be reduced if producers improve the accuracy of their price forecasts, under the assumption that producers have naive expectations, leading to systematic forecasting mistakes. This assumption has come under severe criticism in the last decade.

The rational expectations model assumes that producers use all available information when making forecasts and do not make systematic forecasting mistakes. This model produces a startling result with respect to the social value of S&O information: Specifically, S&O programs *cannot* improve social welfare because producers already know and use all relevant information.

The rational expectation model, however, is based on the strong assumptions that learning is instantaneous and information is costless.

[7] Any improvement is assumed to result in increased speed of convergence to a rational expectations equilibrium.

Incorporating learning behavior and costly information into rational expectation models again suggests public S&O information may improve social welfare. The improvement comes in increasing the speed of convergence towards a rational expectations equilibrium.

A search of the literature revealed only four empirical studies that attempt to directly estimate the welfare benefits of public S&O information, but all four report substantial social welfare benefits associated with public S&O information. For example, Antonovitz and Roe calculate the improvement in social welfare resulting from the adoption of rational outlook forecasts by U.S. fed cattle producers and report a mean social value of the rational outlook forecast of $78 million per year.

The social benefits reported in empirical studies are substantially overstated, however, due to unrealistic assumptions regarding the behavior of market participants, who either do not engage in private information-producing activities or have some form of naive price expectations. It is therefore not surprising that rational outlook information leads to substantial gains in social welfare. It would be more realistic to compare outlook forecasts to the rational expectations of producers. Such a comparison would likely show substantially fewer social benefits associated with the adoption of outlook forecasts.

Further research is needed before firm evidence is available with respect to the economic value of public S&O programs. It is my view that future research should be conducted in a rational expectations framework. Further, the research should determine whether public S&O information increases the speed of convergence to a rational expectation equilibrium. This will require investigation of learning process and the circumstances where public agencies can collect information less expensively than private firms.

Finally, there is a large literature that provides indirect evidence on the social value of public S&O information. Some studies examine the statistical accuracy of outlook forecasts and the impact of the release of outlook information on commodity prices. A comprehensive review of this literature may provide additional insights into the social value of S&O programs.

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Rich Allen: Scott Irwin has done his usual excellent job of summarizing past research on the value of information. There is one thing that has always bothered me about the economic value of information studies. Most of them essentially say that the value of NASS reports can only be calculated if we surprise people. That way they can calculate the market adjustment. However, we want to provide a level playing field of consistent information. It seems to me that there is a significant value to the market if our data are well accepted, and they verify what the market is assuming. That is, there would be no need for market participants to make quick readjustments, change marketing strategies, etc. That avoidance of costs must be worth a great deal if we can figure out how to capture it.
