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Predicting Changes in the Degree of Producer Responsiveness to Policy Shocks

Dermot J. Hayes and Thomas I. Wahl[*]

On April 8, 1989, negotiators at the ongoing General Agreement on Tariffs and Trade (GATT) meetings agreed to begin dismantling the complex set of rules that govern the behavior of agricultural commodity prices. A consensus was reached that governments could better support the income of producers by some form of direct income assistance than by market intervention. It is obvious that any move toward a decoupled agriculture will have large effects on output; indeed, output reduction is one of the factors motivating the agreement. It is also clear that governments will require analysis of the likely impacts on output before they implement the policy changes. It is, however, very difficult to predict how producers will respond to these changes because producers in many countries have grown used to responding to government initiatives rather than to market forces. Under liberalization, the factors causing price movements will themselves be fundamentally altered. It is likely that prices will be more variable and less predictable. Rational producers will be forced to alter the manner in which they predict output prices, which, in return, will invalidate the assumptions that underlie many econometric models of the agricultural sector.

This situation is, perhaps, a classic example of the importance of the Lucas critique. This important idea is based on the argument that policy changes themselves cause changes in the parameters of the models used by governments to predict the impacts of policy changes. The critique is said to invalidate much of the policy analysis that is performed, yet applied economists have never really resolved the problem in a satisfactory manner. Governments continue to demand this type of analysis, and because academics are more comfortable with building models than with guessing, policy analysis is increasing in importance. One very justifiable reason for the continued reliance on econometric models is that the results are less subject to the whims of politicians or to the political agendas of the policy analysts themselves.

Examples of the types of policies that are scheduled to be replaced eventually include the intervention system used in Europe, the price band policies used in Japan, the target price/loan price schemes used in the United States, and the fixed output prices used in some developing countries and in the East bloc countries, including the USSR. In all these cases, the governments currently focus their attentions on controlling the output prices received by producers. The European and Japanese policies involve import restrictions and/or export subsidies whereby domestic consumers subsidize the agricultural sector and, in return, receive a measure of food security. Typically, governments in Europe and Japan announce a price ceiling and a price floor and commit themselves to action, should the price breach either of these boundaries.

As will be shown in this paper, it is difficult to estimate the degree of price responsiveness prevalent in the EC and in Japan under these circumstances because producers who trust their governments can safely ignore market price deviations outside these bands. In fact, whenever prices deviate outside the bands, producers know that governments will act to force the price back to the agreed level.

The policies followed by the governments in the United States and in the USSR are less complicated. In these countries, producers know the price that they will ultimately receive and should respond to the announced target price or planned price as if it were a perfectly predictable market price. However, when governments remove these policies, it is difficult to know how farmers will respond to the sudden importance of market prices.

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alternative forecaster exclusively uses the mean of the target band), then the expected price will equal this mean. In practice, however, there are usually differences between these forecasts.

We can derive explicit measures of these weights using a method originally developed by Lucas that has since become known as the signal extraction problem (Sargent, p. 209).

Let γ be a measure of the producer's confidence in the alternative forecast, $P_{t+1}*$, and let δ^2 be the expected variance of this forecast error, $E[P_{t+1} - P_{t+1}*]^2 = \delta^2$. Let e_{t+1} be the size of the price band or some other measure of the expected forecasting performance of G_{t+1} such that $P_t = G_t + e_t$, and let the variance of this error be τ^2; i.e., $E[e_{t+1}]^2 = \tau^2$. In cases in which the width of the price band is known to producers, τ^2 will be the square of 1/2 of the width of the band. Assume that the producer believes that neither of the alternative forecasts are biased, $E[e_{t+1}] = 0$ and $E[\gamma_{t+1}] = 0$, and that the width of the price band is uncorrelated with prices, $E[P_{t+1}, e_{t+1}] = 0$.

The situation just described is similar to the problem solved by Lucas. There is, however, sufficient difference between the underlying assumptions to make it worthwhile to repeat his analysis in the context of the previous discussion. Lucas does not provide detail on the derivation itself, stating simply that the derivation is done by "straightforward calculation" (p. 134).

First, assume that the producer minimizes the forecast error by using the linear forecast, $P_{t+1} = a_0 + a_1G_{t+1}$. Notice that this forecast does not involve the use of the alternative forecast, $P_{t+1}*$. This term enters later when Lucas assumes that the producer uses the expectations operator as $E[P_{t+1}] = P_{t+1}*$; i.e., the producer's expectation about the next period's price in the absence of information about G_{t+1} is simply the mean value of the alternative forecast. Following Lucas, we can therefore proceed as follows.

The producer will estimate

$$
\begin{aligned}
E[P_{t+1} \mid I_t] &= \min_{a_o, a_1} E\{[P_{t+1} - a_o - a_1G_{t+1}]^2\} \\
&= \min E\{[P_{t+1} - a_0 - a_1(P_{t+1} - e_{t+1})]^2\} \\
&= \min E\{[(1 - a_1)P_{t+1} - a_0 + a_1e_{t+1}]^2\}
\end{aligned}
$$

The first-order conditions are

$$\frac{\partial MSE}{\partial a_0} = -2E[(1 - a_1)P_{t+1} - a_0 + a_1e_{t+1}] = 0$$

$$\frac{\partial MSE}{\partial a_1} = -2E\{[(1 - a_1)P_{t+1} - a_0 + a_1e_{t+1}][P_{t+1} + e_{t+1}] = 0$$

which implies that

$$
\begin{aligned}
& a_0 = (1 - a_1)E[P_{t+1}] \\
& \text{and } (1 - a_1)E[P_{t+1}]^2 - a_0E[P_{t+1}] - a_1\tau^2 = 0 \\
& \Rightarrow (1 - a_1)E[P_{t+1}^2] - (1 - a_1)P_{t+1}* = a_1\tau^2 \\
& \Rightarrow a_1 = \frac{\delta^2}{\tau^2 + \delta^2} \Rightarrow a_0 = \frac{\tau^2 + \delta^2}{\delta^2} P_{t+1}* \\
& \Rightarrow E[P_{t+1} \mid I_t] = \frac{\tau^2}{\delta^2 + \tau^2} P_{t+1}* + \frac{\delta^2}{\delta^2 + \tau^2} G_{t+1}
\end{aligned}
$$

$$\text{or } E[P_{t+1} \mid I_t] = \theta P_{t+1}{}^* + (1 - \theta)G_{t+1} \tag{2}$$

The above equation has much intuitive appeal. The producer will weight the two forecasts on the basis of his confidence in their relative accuracy. If the government has done a good job in the past, then τ^2 will be low relative to δ^2 and most of the weight will be attached to the government's forecast. Once trade liberalization occurs, the size of the government's price band will increase, which will cause the producer to look elsewhere for forecasts; i.e., more weight will be placed on the alternative forecast (δ^2 will be lower than τ^2). The weights θ and $(1 - \theta)$ can be changed arbitrarily for purposes of simulation. The initial values can be estimated econometrically or measured using past forecasting errors.

Equation (2) has some immediate implications for econometric modeling. Normally, one would use either $P_{t+1}{}^*$ or $G_{t+1}{}^*$ when estimating a supply equation. This analysis suggests the use of both in an additive fashion. Also, this equation may help explain why it has been so difficult to estimate the price elasticity of supply. If τ^2 is low, θ will be small and producers will attach very little weight to the alternative forecasts, $P_{t+1}{}^*$, that are used in econometric models.

Notice that this equation offers a systematic method of "weaning" producers from reliance on G_{t+1} and shifting their focus to $P_{t+1}{}^*$. We need only to assume that governments gradually reduce their intervention, thereby reducing their effectiveness in achieving G_{t+1}. If we allow for this reduction in our simulation, the model will automatically shift the weights from G_{t+1} to $P_{t+1}{}^*$.

For the United States and the USSR, we know the initial weights in advance: $\theta = 1$ and $(1 - \theta) = 0$. For Japan and Europe, one cannot be sure that $\theta = 1$. For all the countries, however, the model allows for complete liberalization, i.e., as $\tau^2 \rightarrow \infty$, $\theta \rightarrow 1$. At the end of the transition period, the model implies that producers will use only $P_{t+1}{}^*$; this is a desirable property because it allows one to simulate behavior during and after the policy change.

We can incorporate partial adjustment in a very straightforward manner. Let

$$H_{t+1} - H_t = \lambda(H_{t+1}{}^* - H_t)$$

where H_t is actual breeding inventory or acres planted and $H_t{}^*$ is the desired level of H_t, and let

$$H_{t+1}{}^* = \alpha + \beta E[P_{t+1} \mid I_t],$$

where β is the supply response parameter. We get

$$H_{t+1} = \lambda(\alpha + \beta E[P_{t+1} \mid I_t]) + (1 - \lambda)H_t.$$

Substituting for $E[P_{t+1} \mid I_t]$ from the previous equation, we get

$$H_{t+1} = \lambda\alpha + \lambda\beta\theta P_{t+1}{}^* + \lambda\beta(1 - \theta)G_{t+1} + (1 - \lambda)H_t. \tag{3}$$

The equation suggests a functional form for estimation of inventory equations. It could, however, be modified to reflect the endogenous formation of $P_{t+1}{}^*$, i.e., naive or adaptive expectations. The influence of other exogenous events could also be appended. Notice that we can estimate λ directly. For a given level of λ, we can estimate β by adding the two price coefficients: $\lambda\beta\theta + [\lambda\beta - \lambda\beta\theta] = \lambda\beta$. The weights can be determined by dividing these coefficients. Equation (3) illustrates the importance of the weight θ. Normally, one would ignore this term; therefore, when θ is close to zero, one could greatly underestimate the true degree of price responsiveness, β. Equation (3) also allows us to measure β in an unbiased manner.

Application

Japan has recently agreed to reduce its trade barriers against beef imports. This adds some urgency to the effort to produce a reasonable econometric estimate of the supply responsiveness of the Japanese beef industry. One of the motivations for this research was that the authors have had disappointing results when estimating the responsiveness of Japanese beef producers to price increases. In all the early iterations of this model (i.e., ignoring G_{t+1}), the coefficient on expected price was always negative or insignificant. The authors have documented their attempts at modeling this sector in great detail in previous papers (see, for example, Wahl, Hayes, and Williams). Consequently, the description of the Japanese beef sector that is presented here is brief.

Japan has two distinct types of beef: the native Wagyu (literally translated as Japanese cattle) and beef from Japanese dairy herds. Since 1975, the Japanese have effectively controlled Wagyu beef prices by adjusting their quota on beef imports from the United States and Australia. Each year the Japanese announce a target price for Wagyu and a target price band above and below this announced price. The Japanese government attempts to achieve the target price by annual adjustments in the import quota and uses stocks of frozen beef to achieve the fine-tuning required to keep prices within the band. Occasionally, the Japanese government makes mistakes when setting the quota and is unable to keep prices within the band. Whenever this has occurred in the past, the Japanese government has been forced to adjust the quota in the following year to bring prices back into the target range.

The results presented in (4) are typical of the earlier attempts to model Wagyu breeding inventories.

$$\begin{aligned}\text{Inventories} = {} & \underset{(3.05)}{476.34} - \underset{(-0.79)}{0.05}\ \text{real beef price} + \underset{(4.89)}{1.06}\ \text{inventories}_{t-1} \\ & - \underset{(-3.27)}{0.73}\ \text{inventories}_{t-2} \qquad R^2 = 0.66 \end{aligned} \tag{4}$$

The lagged inventory terms derive from the assumption that producers form their price expectations adaptively and from the fact that we assume that only a proportion of the desired adjustment can be made in any one year. For a discussion on how to incorporate both adaptive expectation and partial adjustment in modeling of this type, see Hayes and Schmitz. Notice that the price term is insignificant and that R^2 is relatively low. If an approximate value of the partial adjustment coefficient can be derived, one can derive the price elasticity of supply from the above model. It is possible to produce slight changes in the above results by using different price deflators or by adding trend variables or intercept shifters. When constructed, none of these alternative models produced significant supply elasticities greater than 0.001. Many of the alternative supply elasticities were negative, and almost none of them were significant. This apparent lack of price responsiveness is explainable within the context of the Japanese livestock system. If prices ever deviate outside of the government's price band, producers can safely assume that the government will correct the error in the following year; hence, producers appear to ignore such price movements. This situation is exactly as described in the theoretical section described previously in this paper.

If we assume that P_{t+1}^* is derived using adaptive expectations and adjust (4) for this assumption, we estimate the following equation.

$$\begin{aligned}\text{Inventories}_t = {} & \underset{(0.24)}{48.4} + \underset{(0.96)}{0.07}\ \text{real price}_t + \underset{(4.08)}{0.25}\ \text{real government price}_t \\ & - \underset{(-3.07)}{0.04}\ \text{real government price}_{t-1} + \underset{(6.69)}{0.95}\ \text{inventories}_{t-1} \\ & - \underset{(-2.97)}{0.65}\ \text{inventories}_{t-2} \qquad R^2 = 0.86 \end{aligned} \tag{5}$$

The interpretation of the coefficients presented in (5) is complex. However, one can derive unique values for the price elasticity of supply as well as the partial adjustment coefficient and the adoptive expectations coefficient. A full interpretation of these results would greatly extend the text; however, it is obvious that the introduction of the G_{t+1} term improved the fit of the equation. The values of the price elasticity of supply are much greater than when this approach was used. The estimated value of θ was 0.02, which reinforces the idea that producers were focusing on G_{t+1} and explains the apparent absence of a supply response.

Simulation

In June 1988, the Japanese government agreed to decouple its farm income support policies, which will result in a 50 percent reduction in real beef prices in Japan. The agreement will be phased in over a six-year period and provides an opportunity to apply the theoretical results and econometric estimates discussed previously. Figure 1 presents three different simulations of this agreement, all of which assume a gradual reduction in Japanese beef prices. The projected inventory path labeled "w/o govt" is the inventory response one would receive without the additional G terms; i.e., using equation (4). The path labeled "adding coef" is the inventory response with the addition of G terms, assuming that both the alternative forecast and the government forecast agree; i.e., equation (5) with $G_{t+1} = P_{t+1}^*$. This inventory response is more in line with prior expectations and is from other projections produced without the benefit of econometric models. The path labeled "chging wts" assumes that the value of θ increases in ten equal installments from 0 to 1 and that the government maintains the same G_{t+1} each year but that it widens the band within which it agrees to maintain beef prices.

In this last scenario, we arbitrarily assume that producers initially make their forecasts on the basis of the government price and gradually place more emphasis on the alternative forecast. This will happen as governments gradually reduce their market intervention and therefore their ability to influence prices. This latter simulation demonstrates the importance of this methodology. By changing θ, one can use parameters estimated in a period during which governments influence prices to predict behavior as this intervention is reduced and eliminated. This can be achieved without the need for ad hoc specification about the level or change in any of the parameter values. This method allows us to get some idea of how rational producers will react to decoupling without the need for subjective input from the modeler.

Summary and Conclusions

As governments replace current price support policies with direct income support, the prices received by producers will almost certainly fall dramatically. Also, producers will no longer be able to rely on government intervention to stabilize commodity prices. These changes will alter the way producers respond to prices in a way that is difficult to model. This paper focuses on predicting how producers will adapt to the mechanisms by which they form price expectations under these new circumstances. It is argued that, in the past, rational producers have used weighted averages of the announced government price and the price predicted by alternative forecasting mechanisms and that these weights depend on the expected forecast accuracy of the two forecasts. This approach offers a useful way to simulate the impacts of decoupling. As the ability of governments to control prices decreases, so too will the accuracy of government forecasts. If we are prepared to specify in advance how the accuracy of governmental forecasts will change or how price bands will be adjusted, then we can specify the weights that will be used by rational producers. When governments get out of these markets, the weights attached to government behavior will approach zero. This approach, therefore, offers a way to gradually shift the emphasis of producers from controlled prices to world market prices within the context of policy simulations. An interesting implication of this work is that supply equations which ignore government prices will underestimate the true price responsiveness of producers. We show that by incorporating target prices in the econometric specification, the true supply response term can be derived.

Japan has begun to liberalize its beef market in a manner that is consistent with the assumptions that underlie the theoretical model. Using a model of the breeding herd inventory of the Japanese cattle industry, we also show how the theoretical results can be implemented. The results emphasize the sensitivity of projected breeding inventories to assumptions about the formation of price expectations. The simulations based on the proposed specification model are more realistic than those derived from the more traditional econometric specification.

The analysis presented here suggests that, provided one is prepared to make some additional assumptions, one can simulate the impacts of trade liberalization agreements even in cases in which the price determination process is transferred from the government to competitive markets.

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