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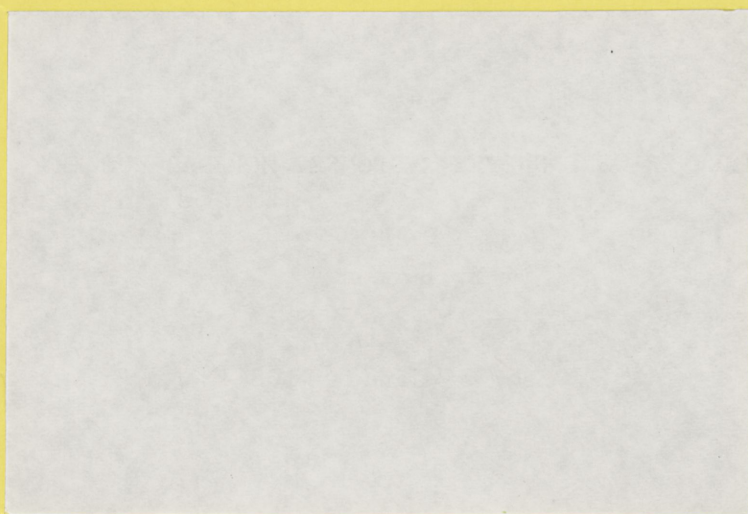# Agricultural Economics

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This paper hopes to extend the work of Traill, Colman and Young [1978] on irreversible supply functions, and consists of 3 parts. In the first a dislocation between the theoretical basis of the model and its empirical application is noted, which can cause estimation difficulties if the data set has particular properties. The data set used in the study has these properties and the robustness of the estimates for the modified Wolffram (M.W.) method are questioned. In the second, an adjustment is suggested to the method of partitioning the data set which avoids this problem, and an empirical example presented. In the third the adjustment mechanism under conditions of asset fixity is re-examined and the use of lagged dependent variables and distributed lags questioned. An alternative is proposed, based on a modified partial adjustment model.

The Problem of Eternal Assets

Throughout the paper the following specification of the M.W. model is used

$$A_t = a_o + a_1 P_t^e + a_2 P_t^{emax} + \varepsilon_t \qquad [1]$$

where A_t is the acreage planted, P_t^e is the price farmers expect to receive in period t, and p_t^{emax} is the maximum such price that has occurred, including P_t^e. Thus for price levels below the maximum a_1 is the response coefficient, but for price levels above the previous maximum (i.e. if $P_t^e > P_{t-1}^{emax}$ so that $P_t^{emax} = P_t^e$) $a_1 + a_2$ is the response coefficient. The rationalization for this is that for price falls below the previous maximum the fixed assets are not disposed of because of their low salvage value. Therefore as price rises again there will be no new purchases of the asset until all of the slack has been taken up, which is assumed to occur when the price reaches its previous maximum. A more elastic response then occurs for further price rises. As Traill et al. points out, this method of segmenting the data is only relevant for the short run, as

depreciation will erode even the most highly "fixed" asset in the long run. However, when generating P_t^{emax} empirically there is no historical limit; price has to rise to above P_{t-1}^{emax} before there is an elastic expansion in output, however many years before that maximum occurred. This implies that once bought the asset exists for ever. This will cause severe estimation difficulties if there is a high price early on in the data set that is never surpassed as the P_t^{emax} variable will effectively become a constant.

Inspection of the data set used by Traill et al. reveals this to be the case, with a high price occurring in 1953, the second observation, which is not surpassed until 1973. This implies that the investment made in 1953 was still intact 20 years later, and that the coefficient a_2 has been estimated using 3 observations. Under these circumstances we should have little confidence in the parameter estimates given for the M.W. equation in Table 2 of Traill et al. (p.530) and in order to test this, the equation was re-estimated with a truncated data set. The results are given in Table 1 below, with the results using the full (1952-1974) data set for direct comparison.

TABLE 1[†]

Data Period	Constant	P_t^e	P_t^{emax}	r^2[$]
1952-1974	32.604 (3.61)	1.622 (2.56)	4.798 (2.55)	0.441
1952-1973	43.625 (6.33)	1.404 (3.09)	2.585 (1.81)	0.432
1953-1974	-27.401 (1.77)	0.645 (1.25)	17.637 (5.37)	0.711

[†] t statistics in parenthesis

[$] r^2 is the unadjusted correlation coefficient, to conform with the original paper

The changes that occur are quite dramatic, confirming the fears expressed about the calculation of P_t^{emax}. In the next section a modification is

suggested which brings the empirical application of the model closer to the theoretical derivation of the data partitioning.

The 'Window' (or further modified Wolffram) Technique

To restate the difficulty: The data segmentation method is relevant for the short run only, but the method of empirical application may imply long run effects, or alternatively, an implausably long short run. One method of capturing the decline in productive capacity of an asset over time would be to define P_t^{emax} as being the maximum price that has occurred in the past n years, where n has to be determined empirically. This ensures that at some point, historically high levels of investment cease to have an impact on current output decisions.

Several series of P_t^{emax} were generated using "windows" of differing lengths (i.e. for varying values of n) and equation 1 re-estimated using these. The r^2 coefficient rose up to the 6 year window and then declined. The estimates using the 6 year window are given below.

TABLE 2

Data Period	Constant	P_t^e	P_t^{emax}	r^2
1952-1974	37.296 (6.28)	1.482 (2.47)	4.198 (3.16)	0.506

This fairly simple technique has given an improvement in r^2 over the M.W. method, and more importantly is relatively stable for differing data periods. The elasticity of response to changes in price above the previous maximum is 0.3 and the impact elasticity of response to price changes below the maximum is 0.08. It is of interest to note that the long run elasticity for price falls is equal to that for increases in price above the maximum. What the model also implies is that there are no costs of adjustment apart from those implied by asset fixity. In Traill et al. this assumption is relaxed, and the inclusion of lagged dependent variables and distributed

lags on the price series used to capture these effects. However, when one considers the problem of adjustment through time in conjunction with asset fixity it becomes clear that what we have been considering up to now is just the first adjustment in a whole series, and that the whole process should be modelled in an internally consistent manner. The next section will present an attempt to achieve this.

The Adjustment Process

Irreversible supply response has its basis in the idea that it is not possible to adjust output downwards as fast as it is upwards due to the cost of disposing of assets and the resulting asset fixity. It would therefore seem plausible that the partial adjustment model could be adapted so as to provide a framework within which to model the problem.
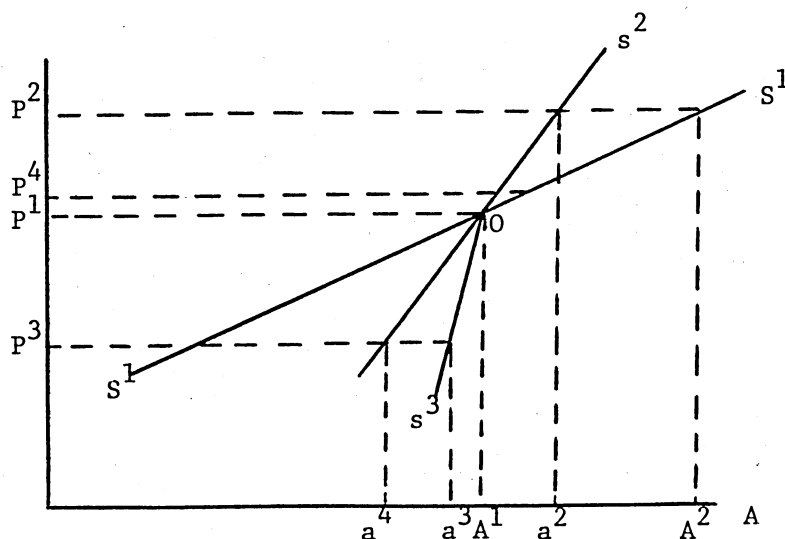

Figure 1

Let S'S' be the long run supply curve, with output initially at A^1. If the price rises from P^1 to P^2 then the long run output is A^2, but because of the conventional costs of adjustment, output increases to a^2, giving a short run supply curve os^2. This response can be modelled by an equation of the form:

$$A_t - A_{t-1} = b_1[A_t^* - A_{t-1}] \quad 0 < b_1 < 1 \qquad [2]$$

where A_t^* is desired long run output

with no asset fixity, a fall in price from P^1 to P^3 would reduce supply to a^4 in the first period, but because of the additional constraint on reducing investment we move to a^3. This response can be modelled by an equation of the form:

$$A_t - A_{t-1} = b_2[A_t^* - A_t] \qquad 0 < b_2 < 1 \qquad [3]$$

and we expect $b_2 < b_1$.

These can be combined into a single equation

$$A_t - A_{t-1} = b_1[A_t^* - A_{t-1}].D + b_2[A_t^* - A_{t-1}][1-D] \qquad [4]$$

where D is a dummy variable taking a value of 1 if $A_t^* - A_{t-1}^{max}$ is +ve and zero otherwise. A_{t-1}^{max} is the previous maximum output level, and replaces P_{t-1}^{max} as the criterion by which we decide if output is to respond elastically or not. The need for this change is indicated by considering a small decrease in price from P^2. By the old criterion, price will have fallen below the previous maximum, and therefore response should be inelastic. However, the long run desired output will still be in excess of the previous output, so an increase in existing asset holdings is needed, not a contraction.

A_{t-1}^{max} is constructed using the window technique described above, but in order to simplify the exposition and give us a fixed point of reference rather than a moving one, it will be assumed to remain constant in the following discussion.

s^3os^2 is the familiar kinked S.R. supply curve, but unfortunately Eq.4 does not adequately represent it. Let us return to our initial position of P^1A^1, where A^1 is the current maximum, and then reduce price to P^3, causing output to fall to a_3, and then increase price to P^2. The change in output $a_2 - a_3$ is no longer a simple proportion of the

difference between desired and lagged output, $A^2 - a^3$. If the initial

output is below the previous maximum and desired output lies above it,

the change in output can be considered in two parts, $A^1 - a^3$, which is

taking up the slack in the fixed asset, and $a_2 - A^1$, which will be affected

by the "usual" adjustment costs. Thus Eq.2 has to be adjusted to

$$A_t - A_{t-1}^{max} = b_1[A_t^* - A_{t-1}^{max}] \qquad 2a$$

the need for this adjustment is revealed if the change in output generated

by 2 is compared for a change in P^3 to P^2, and P^4 to P^2. Combining 2a and

3 together gives

$$A_t - A_{t-1}^{max} \cdot D - A_{t-1} \cdot [1-D] = b_1[A_t^* - A_{t-1}^{max}] \cdot D + b_2[A_t^* - A_{t-1}][1-D] \qquad [5]$$

This specification is, however, too restrictive. For example, consider

Figure 2 where price has been reduced from P^1 to P^2 and output from A^1

to a^2, and price has then been increased from P^2 to P^3. How will output
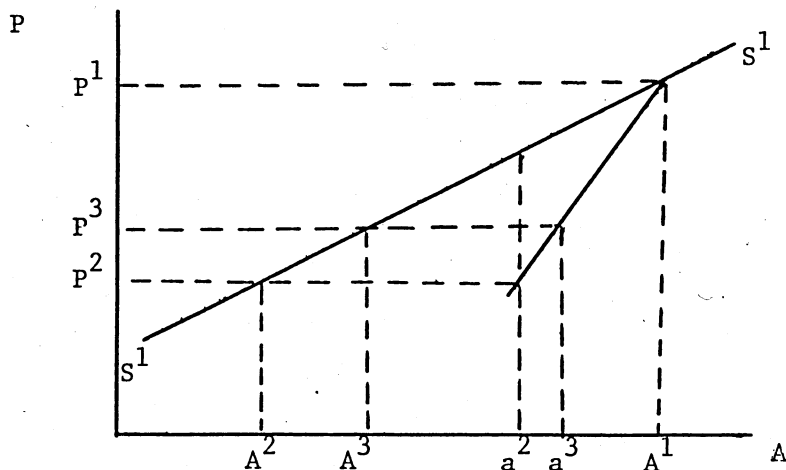
respond?

Figure 2

We must first consider the method by which output has been reduced from A^1

to a^2. The lower product price will mean a reduction in the variable

inputs that can profitably be used and there will also be some reduction

in the fixed asset due to depreciation. The discussion that follows

revolves around the relative weight of each of these factors.

If the response follows the specification of Eq.2 then output will be reduced to below a^2 in response to the rise in price. Under some circumstances this is quite reasonable: the long run equilibrium output at P^3 is A^3, substantially below a^2, and so output will be reduced further if possible. In order to do this the reduction in output due to the continued depreciation of the asset has to outweigh the increase in output caused by the increased use of the variable inputs that the higher product price allows. The problem with Eq.2 is that it does not allow the reverse, it does not allow output to increase beyond a^2. That this is a possibility is shown by considering the case of an asset which shows no depreciation in its early years. The original movement from A^1 to a^2 must be achieved by reducing the variable inputs, and the increase in price to P_3 should cause output to move to a^3.

Equation 5 can be easily extended to accommodate these factors by creating a suitable dummy variable and using it to alter the adjustment coefficient b_2. The full equation now becomes

$$A_t - D. \ A_{t-1}^{max} - [1-D]A_{t-1} = b_1[A_t^* - A_{t-1}^{max}].D + [b_2 + b_3D_2][A_t^* - A_{t-1}][1-D] \quad [6]$$

where D_2 is defined as $=1$ if $P_t > P_{t-1}$

0 otherwise

This specification lends to some interesting problems for estimation which are dealt with in the Appendix. It has been estimated using the onion data of Traill et al., with both a 6 year window and a 3 year window to calculate A_{t-1}^{max}. The restrictive assumption of naive expectations has been dropped, and a distributed lag formulation used instead. The long run desired output is defined as

$$A_t^* = b_4 + b_5 \ P_{t-1} + b_6 \ P_{t-2} + b_7 \ P_{t-3} \qquad [7]$$

The results are given in Tables 3 and 4 below.

TABLE 3

b_3 constrained to equal zero

Coefficient[†]

	b_1	b_2	b_3	b_4	b_5	b_6	b_7	s^2[$]
6 year window	0.236 (0.76)	0.799 (3.94)	– –	42.245 (7.14)	2.618 (2.71)	2.437 (2.92)	0.919 (1.12)	0.732
3 year window	0.304 (1.20)	0.824 (3.98)	– –	41.756 (7.64)	2.720 (3.01)	2.437 (3.16)	1.021 (1.34)	0.742

† t statistics in parenthesis

$ when estimating using full information maximum likelihood methods the usual test statistic are not available. In order to give some means of comparison a statistic has been calculated using the same formula as the r^2 statistic, but for which it may not be legitimate to claim the usual properties.

$$s^2 = \frac{\Sigma\, e_i^2}{\Sigma (A_i - \bar{A}_i)}$$

TABLE 4

D_2 defined as = 1 if $P_t > P_{t-1}$

0 otherwise

Coefficient

	b_1	b_2	b_3	b_4	b_5	b_6	b_7	s^2
6 year window	0.229 (0.41)	0.160 (0.44)	0.759 (1.70)	45.939 (7.63)	2.187 (1.94)	1.568 (0.88)	0.881 (1.13)	0.736
3 year window	0.402 (0.85)	-0.046 (0.19)	1.106 (3.33)	47.549 (9.10)	2.203 (2.08)	0.889 (0.50)	0.973 (1.41)	0.739

The first feature of these results is the rather small adjustment

coefficient for increases above the previous maximum (b_1) which also

tend to be insignificant. In Table 3 the adjustment coefficients for a fall in price (b_2) are large, but they are substantially reduced in Table 4, where the coefficient b_3 assumes the greater role. b_3 seems to suggest that, for the price variations considered in the data set, a price increase that occurs when there is excess capacity enables output to very nearly achieve the desired long run level.

The irreversibility hypothesis does not emerge in a good light from these results. In Table 3 the a priori expectation of the relative size of b_1 and b_2 is confounded, and in Table 4 the coefficients are not significant. Some tentative explanation of these results is given in the conclusions that follow.

Conclusions

This paper accepts as true the central premise of the Traill, Colman and Young paper: that slack input capacity will be taken up before new investment will be undertaken, and that the output elasticity w.r.t. increasing price will not be a constant. However, the modified Wolffram method of translating this into an empirical estimating equation is found wanting under some circumstances, with the formulation of P^{max} implying no long run depreciation in the asset. The window method of generating the price series as suggested in this paper gives a limit to the period over which an investment high can affect output. The empirical application of the method presented above gives support to the use of the method.

The attempt to incorporate the adjustment problem posed by asset fixity into a partial adjustment framework seems to raise more questions than it answers. The proposition that the respond beyond the previous maximum is more elastic than when there is slack capacity is not convincingly supported at all. It may be that, for the particular industry studied and over the data range used, irreversability does not exist. An

alternative explanation is that, with irreversability and uncertainty about future price levels, farmers are reluctant to expand output when prices rise. Before venturing into this seemingly torturous area, it would be useful if the methods developed in this paper were applied to other sectors, in order to get a better understanding of their value.

References

Traill, B., Colman, D. and Young, T. (1978). Estimating Irreversible Supply Functions. American Journal of Agricultural Economics, 60, 528-531.

APPENDIX

The problem arises in the calculation of the dummy, D. If D is defined as

$$D = 1 \quad \text{if } A_t^* > A_{t-1}^{max}$$

$$\quad\quad 0 \quad \text{otherwise}$$

it cannot be constructed as an exogenous variable because prior information is needed of the parameters of Equation 6 in order to generate A_t^*. Specifically D is defined within the estimation procedure as

$$D = \frac{|A_t^* - A_{t-1}^{max}|}{A_t^* - A_{t-1}^{max}} \cdot \tfrac{1}{2} + \tfrac{1}{2}$$

The package used for estimation can cope with the inclusion of such a variable, and therefore the value of the dummy and A_t^* are solved for simultaneously, and are consistent with each other.