SUPPLY RESPONSES IN THE SOUTH AUSTRALIAN POTATO INDUSTRY

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The potato industry in South Australia is characterized by very unstable prices. One hypothesis for this instability is that potato growers' acreage responses follow a cobweb pattern, that is, a one year lag of acreage to price. This hypothesis is tested, together with a two year lag and a distributed lag. The distributed lag model seems the most satisfactory and gives a short-run elasticity of acreage to price of 0·36 and a long-run elasticity of 1·09. An alternative to the lagged price hypothesis is the "constant cash return" hypothesis which postulates that potatoes are grown to provide a certain cash income to permit farm development. This explanation of acreage response only seems relevant in the dairying and fat lamb areas of the State.

There have been a number of studies on the potato industry in Australia and in individual States.[1] However, there has been little attention paid to the industry in South Australia and still less attention paid to estimating supply elasticities for an industry which has been characterized by notoriously unstable prices. The potato industry in South Australia is by no means large either absolutely or relative to other primary industries —the average annual gross value of the crop over the period 1953-54 to 1963-64 being only $1·8m. The number of growers registered by the South Australian Potato Board has never exceeded 2,000. Only growers intending to sell in South Australia are licensed by the Board, growers intending to sell interstate not having to register. However, practically all growers are registered since registration does not prevent a grower from selling potatoes interstate. South Australia is almost self sufficient in potatoes, only having to import small quantities from September to November in years of low local production. For the remainder of the year, potato production in South Australia is in excess of local requirements and there is some export interstate, particularly to New South Wales. Although no official estimates of this interstate movement are available it is probably of the order of 15 to 25 per cent of annual local production.

All potatoes sold in South Australia must go through the South Australian Potato Board. After receival and weighing, potatoes are distributed to wholesale merchants from whom retailers buy. The Board sets the prices paid by merchants, retailers and final consumers. In order to present a more attractive product, 30 to 35 per cent of potatoes marketed in South Australia are washed before sale. There are four washers

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[1] *The Australian Potato Industry,* Bureau of Agricultural Economics, Canberra, 1949, pp. 67; *Report on the Australian Potato Industry,* Bureau of Agricultural Economics, Canberra, 1953, pp. 38; R. N. Smith, "Tasmanian Potato Marketing Organization", *Rev. Marketing and Agricultural Economics,* Vol. 14, 1946, pp. 440-443; Anon., "Potato Marketing Scheme, Western Australia", *Rev. Marketing and Agricultural Economics,* Vol. 4, 1939, pp. 67-70; and J. van der Meulen, "The Organization of the Sydney Potato Trade", *Rev. Marketing and Agricultural Economics,* Vol. 28, 1960, pp. 207-223.

licensed by the Board and for washing and grading these four agencies are paid a fee by the Board. Growers are paid once a month by the Board after deducting any amounts for freight, bags, etc. as well as the levy which growers are obliged to pay the Board. Potato marketing in South Australia is relatively simple in contrast to the Sydney market with its system of primary and secondary wholesalers, retailers, country agents and merchants.[2]

Until an amendment to the original South Australian Potato Marketing Act (1948) was passed in 1964, the Board had no power to buy or sell on its own behalf. Its powers were restricted to registering both growers and merchants, to controlling prices and to fixing a quota for the amount of potatoes to be received from each registered grower. If a grower produced more than his quota, he could store the excess or dispose of them interstate. The extent to which the Board has flexibility in setting local potato prices is extremely limited. The Board could not, until 1964, buy potatoes for stockpiling. Moreover, the Board cannot control interstate movements of potatoes for Constitutional reasons. Any attempt to maintain the South Australian price above that prevailing in Eastern States, apart from the cost of the transport differential, would have resulted in a flow of potatoes into South Australia. Similarly, any attempt to maintain South Australian prices below those prevailing in Eastern States, again apart from the transport differential, would have resulted in an outflow of potatoes from South Australia. In fact, the Board's pricing policy seems to have been one of "follow the leader" where the leader is the price for potatoes prevailing in the Sydney market. Figure 1 illustrates the extent to which the Board adjusted South Australian prices in the light of movements in Sydney prices. The Board's ability to insulate South Australian potato prices from interstate prices is quite limited. However, since five of the nine members of the Board are potato growers, the Board may provide some countervailing power against highly concentrated buying power in the hands of merchants or retailers.

There are two main potato growing areas in South Australia. These are the Local and South East areas. Local refers to the Adelaide hills area and South East refers to the area around Mount Gambier. Within these two main areas, which have fairly moderate climates, weather conditions do not greatly influence the supply of potatoes since irrigation of potato crops is widely practised. Also, the use of certified seed has reduced the effect of plant diseases on potato production. There are three potato seasons in South Australia. The first is the early season crop, which is planted from April to August. The second is the mid-season crop, which is planted from September to October and the third is the late season crop which is planted from November to March. These three seasons appear to be the general rule throughout Australia, although reference has been made to a fourth season in New South Wales and Queensland.[3] The late season crop is by far the most important throughout Australia. In South Australia it accounts for over 75 per cent of annual production, mainly as a consequence of the better storing qualities of late season potatoes relative to early and mid-season potatoes.

One argument which is commonly advanced to explain the instability in potato prices is that growers' response to prices is a lagged one and

[2] van der Meulen, *op. cit.*

[3] White, L., "Potato Industry—Reasons for Shortage in Australia", *Quarterly Review of Agricultural Economics,* Vol. 5, January 1952, pp. 16-20.

that the price elasticity of demand for potatoes is very low. That is, the per capita consumption of potatoes is relatively insensitive to price changes and moreover the income elasticity of demand for potatoes is also low. Given these two low elasticities the hypothesis which is advanced to explain the variability of potato prices is developed along the

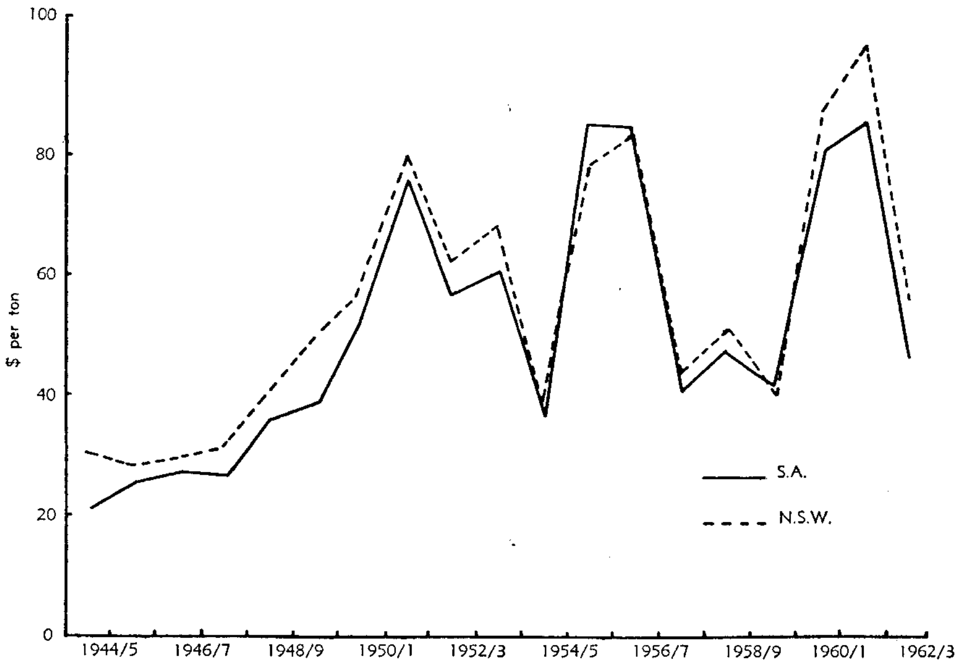

FIG. 1—Annual average of gross prices received for potatoes by South Australian and N.S.W. growers, 1944-45 to 1962-63.

following lines. Suppose that in a certain period t, an unusually large quantity of potatoes is produced. This results in a very substantial fall in potato prices in period t. In the following period, $t + 1$, in view of the low price obtained in period t, growers will plant fewer acres to potatoes. As a consequence, the volume of potato production will fall in $t + 2$ and there will be a sharp rise in potato prices. This, in turn, will induce growers to plant more potatoes and there will be a fall in prices in $t + 3$. This model is, in effect, a simple cobweb model. In this simple form the model is rather mechanistic and makes the critical assumption that potato growers base their plans for future production on the expectation that current prices will continue. This simple cobweb model has the equational form:

(1) $$X_t = a + b_1 P_{t-1}.$$

If we were to elaborate this simple cobweb model we might postulate that acreage responses follow a more complicated lag pattern, for example, that acreage response at time t is related not only to prices at $t - 1$ but also to prices at $t - 2$, or even longer lags. For a two year lag we would have the supply function

(2) $$X_t = a + b_1 P_{t-1} + b_2 P_{t-2}$$

which we might call the complex cobweb formulation.

Nerlove[4] has developed the use of distributed lag models for situations where the effect of a price change is distributed over a number of periods. Various time paths for the distribution of lag may be assumed; for example, logistic, exponential or normal. We have used a time path which assumes that the effect of a price change declines geometrically with time, a distribution of lag which is attributable to Koyck.[5]

In general terms, suppose we let time be measured as a discrete variable and let the supply equation be of the form:

$$X_t = a + \sum_{i=o}^{\infty} b_i P_{t-i} \tag{3}$$

where X_t is the quantity supplied in period t; P_t is the price in period t; and the b_i are constants. The assumption is then made that after a certain point, say $i = k$, the series of coefficients b_i, $i = 0, 1, \ldots$ can be approximated by a convergent geometric series, so that $b_{k+m} = \gamma b_{k+m-1}$. This implies $b_{k+m} = \gamma^m b_k$, where $m \geqslant 0$, and $0 \leqslant \gamma < 1$. The supply equation now becomes:

$$\begin{aligned} X_t &= a + b_o P_t + \ldots + b_{k-1} P_{t-k+1} \\ &\quad + b_k P_{t-k} + b_k \sum_{m=1}^{\infty} \gamma^m P_{t-k-m}. \end{aligned} \tag{4}$$

Thus X_t is a function of the current price, of k unweighted lagged prices, and of a geometrically weighted average of all other past prices.

Before applying this equation to the South Australian potato industry an adjustment has to be made to it. Since growers do not know what the price in year t will be until after they have produced the crop for year t, the variable P_t is irrelevant and has been omitted from the final model.

Thus equation 4 becomes:

$$\begin{aligned} X_t &= a + b_1 P_{t-1} + \ldots + b_{k-1} P_{t-k+1} \\ &\quad + b_k P_{t-k} + b_k \sum_{m=1}^{\infty} \gamma^m P_{t-k-m}. \end{aligned} \tag{5}$$

The effect of a price change is assumed to decline geometrically after a certain period $t = k$. It is not unreasonable to assume that, with respect to the South Australian potato industry, this takes place after the first period following a price change, i.e. $k = 1$.

Putting $k = 1$ in equation 5, by simple algebraic manipulations[6] we obtain the distributed lag supply function:

$$X_t = a(1 - \gamma) + b_1 P_{t-1} + \gamma X_{t-1} \tag{6}$$

from which we may estimate the parameters $a(1 - \gamma)$, b_1 and γ.

Again following Nerlove,[7] from equation 6 the short-run elasticity of acreage with respect to price lagged one period is given by $b_1 P_{t-1}/X_t$. The long-run elasticity of acreage is derived from the cumulative effect on acreage of a maintained price change in P_{t-1}. This acreage effect is given by $b_1/(1 - \gamma)$ and hence, the long-run elasticity of acreage is given by $(b_1/1 - \gamma) P_{t-1}/X_t$.

[4] Nerlove, M., *The Dynamics of Supply*, Johns Hopkins Press, Baltimore, 1958, pp. 267; and *Distributed Lags and Demand Analysis for Agricultural and Other Commodities*, United States Department of Agriculture Handbook No. 141, Washington, 1958, pp. 121.

[5] Koyck, L. M., *Distributed Lags and Investment Analysis*, North Holland, Amsterdam, 1954, pp. 111.

[6] Nerlove, M., *Distributed Lags and Demand Analysis . . . .*, *op. cit.*, p. 13.

[7] *Ibid.*, p. 13.

We have postulated that the control variable so far as potato producers' supply responses are concerned is acreage rather than physical production. For this reason we have estimated the three models of equations 1, 2 and 6 using data on the number of acres planted by registered potato growers in South Australia and the deflated price of potatoes received by growers over the period 1952-53 to 1963-64. The actual data are given in Table I of the Appendix. The least squares estimates of the results are given in Table 1.

TABLE 1

Least Squares Estimates of Supply Equations (1), (2) and (6)

Equation	Constant	Variable			R^2
		Price lagged one year	Price lagged two years	Acres lagged one year	
(1)	4,473	99·5			0·22
(2)	1,916	101·0	81·5		0·36
(6)	—622	89·0**		0·668**	0·83

** Significant at the one per cent level.

The distributed lag model fits the data well and both coefficients are highly significant. The short-run price elasticity of acreage implied by this model is 0·36, and the long-run elasticity is 1·09. In both cases the elasticities were evaluated at the mean values of price and acres.

Although the distributed lag model fits the data quite well and gives coefficients which are consistent with *a priori* expectations as to sign, one further hypothesis will be tested. We have distinguished two main potato producing areas in South Australia. The first is the Local area and the second is the South East. The Local area is predominantly market gardening where potatoes are grown in combination with other vegetables, although there are some dairying and fat lamb properties. Over 70 per cent of the total acreage planted by registered growers is in this area. The South East area is principally a fat lamb and dairying area where potatoes are grown not so much as a component of a long-term optimum product mix but rather to provide a quick cash return for farm improvement and land development, i.e. as a short-run device for hastening the achievement of the long-run optimum product mix. In these "cash return" districts we would expect that if prices rise and/or yields increase, fewer acres of potatoes would be required to provide a given amount of cash.

In order to test the "cash return" hypothesis it is necessary to disaggregate the total acres planted by registered growers in the two potato growing areas. Since data are also available for each of three potato seasons it was decided to disaggregate by seasons also. The model considered for each area was the following:

(7) $$X_{it} = a + b_1 P_{it} + b_2 Y_{it-1}$$

where X_{it} = the number of acres planted by registered growers in each area in season i in year t;

P_{it} = the deflated price in each area at the time of planting for season i in year t in \$ per ton;

Y_{it-1} = yield in tons per acre in each area for season i for the previous year.

Data on yield per acre disaggregated on an area and seasonal basis were not available so that the yield variable used was the aggregate figure for the whole year. The yield variable was lagged one year on the *a priori* ground that it was yield in the immediate past which was most likely to affect growers' decisions on acreage planted.

In the choice of the appropriate price variable, it was decided that the most relevant price was that ruling in the market at the time when each season's crop was being planted. An official series of prices for each season was not available. However a series of unit gross values in \$ per ton for each month of the year was calculated from data obtained from the records of the South Australian Potato Board. This series was calculated by dividing the quantity of potatoes delivered to the Board by growers into the gross value of deliveries. To obtain a series of what we shall call the "planting price", a simple unweighted average of these unit gross values was calculated for the three-month period encompassing one month immediately prior to the beginning of each season's planting and the first two months of each season's planting. These unit gross values were then deflated by an index of prices paid by farmers. The series of deflated average unit gross values, together with the acreage and yield figures for each season, are presented in Tables II and III of the Appendix. The results of estimating equation 7 using annual observations from 1952-53 to 1963-64 are given in Table 2.

TABLE 2

Least Squares Estimates of Supply Equation (7)

Area and season	Constant	Variable		R^2
		Price	Yield	
		(\$ per ton)	(Tons per acre)	
Local				
Early season	780	1·85	56	0·12
Mid-season	3,038	— 3·31	— 201**	0·62
Late season	3,766	— 10·35	— 135	0·21
South East				
Early season	438	0·68	— 47**	0·66
Mid-season	1,404	— 3·33	— 113*	0·41
Late season	10,642	— 43·20**	— 1,004**	0·90

** Significant at the one per cent level.
* Significant at the five per cent level.

The low coefficients of multiple correlation obtained for the early and late seasons in the Local area suggest that the "constant cash return" effect is not operating in these cases. In fact the signs on both price and yield coefficients in the early season are inconsistent with the "cash return" hypothesis.

Since most potatoes grown in the Local area are grown in a market garden rotation with other vegetables, we would expect potatoes in this district to form part of the grower's optimum product mix. The grower's response to a price change would then be more likely to be of the type suggested by the distributed lag model and not that suggested by the "constant cash return" hypothesis. In the mid-season in the Local area, the fit obtained for equation 7 is not exceptionally good. The signs on both price and yield coefficients are negative, as would be expected if the "constant cash return" effect was operating, although only the yield coefficient is significant. These results do tend to conflict with what we would expect to be a Local grower's behaviour, and are difficult to explain. Perhaps on market gardens the relative shortness of the mid-season or the profitability of competing crops precludes mid-season potatoes so that they are largely grown only on Local dairy or fat lamb properties with a "constant cash return" effect operating.

In the South East, where potatoes are grown principally on dairying and fat lamb properties, we would expect the "cash return" hypothesis to be most relevant. The results in Table 2 for the late-season crop—which averaged over 70 per cent of total acreage planted in the South East—strongly support the "cash return" hypothesis. The fit is good and both coefficients have the expected signs and are highly significant. For the other two seasons the support of the hypothesis is not as strong. The fits are only moderate, although the coefficients (with one exception) have the expected sign and only the coefficient on the yield variable is significant.

The distributed lag model seems to explain annual fluctuations in the total acreage sown by registered potato growers in South Australia fairly well. However, in the South East, the fluctuations in acreage planted seem to support the "cash return" hypothesis. It is not our purpose to make any far reaching policy conclusions on the basis of these results. We do believe, however, that we have shown that the simple cobweb argument, which is often advanced as an explanation of the instability of potato prices, is not suported by the available evidence. Indeed, the evidence supports a more complicated response pattern with a tendency for a "constant cash return" type of response in the South East to dampen the distributed lag response of total acres sown.

Appendix

TABLE I

Acres Planted and Prices Received by Registered Growers

Year	Acres	Deflated price ($ per ton)
1950/51	n.a.	35·10
1951/52	n.a.	42·72
1952/53	12,255	27·70
1953/54	10,314	30·40
1954/55	9,448	18·52
1955/56	5,790	44·10
1956/57	6,769	41·32
1957/58	7,894	17·62
1958/59	6,502	22·34
1959/60	6,743	18·96
1960/61	5,542	34·60
1961/62	5,786	36·84
1962/63	6,410	19·52
1963/64	5,543	19·78

Sources: The series of acres planted was obtained from the records of the South Australian Potato Board. The series of prices was obtained from the series of gross prices paid to growers in the South Australian *Statistical Register,* Part V(a), deflated by the B.A.E. index of prices paid by farmers. "Gross" refers to the fact that no allowances are made for freight, bags, levies, etc.

TABLE II

Real Average Unit Gross Values by Season
($ per ton)

Year	Real average unit gross values		
	Early season	Mid-season	Late season
1952/53	33·92	31·18	23·70
1953/54	25·58	47·98	50·60
1954/55	25·90	14·48	14·38
1955/56	25·42	41·16	51·06
1956/57	45·10	103·34	58·34
1957/58	30·58	18·34	20·90
1958/59	12·98	15·04	31·48
1959/60	26·10	15·38	24·54
1960/61	15·50	27·32	33·12
1961/62	46·74	54·16	56·14
1962/63	19·88	30·64	31·94
1963/64	10·46	13·84	14·36

Source: The series of average unit gross values were calculated from records of deliveries and gross values of deliveries to the South Australian Potato Board and were deflated by the B.A.E. index of prices paid by farmers.

TABLE III

Acres Planted (Disaggregated by Season and District), and Yield for Registered Growers

Year	Yield (tons per acre)	Acres planted					
		Local district			South East district		
		Early	Mid	Late	Early	Mid	Late
1952/53	4·75	1,457	2,102	3,260	269	953	4,214
1953/54	6·41	1,208	1,904	2,792	243	629	3,538
1954/55	6·35	1,232	1,717	2,202	140	625	3,532
1955/56	6·79	943	1,356	1,711	71	245	1,464
1956/57	7·69	1,166	1,328	2,361	136	375	1,403
1957/58	7·98	1,237	1,359	2,889	128	577	1,704
1958/59	8·20	1,052	1,165	2,537	69	361	1,318
1959/60	8·30	1,208	1,390	2,335	108	558	1,144
1960/61	7·80	1,179	1,124	2,053	57	351	794
1961/62	9·10	1,221	1,278	2,214	64	359	650
1962/63	9·00	1,695	1,328	2,397	39	331	619
1963/64	9·38	1,313	1,201	2,211	16	215	587

Sources: The series on yield per acre was obtained from the South Australian *Statistical Register,* Part V(a). The disaggregated series of acres planted was obtained from the records of the South Australian Potato Board.