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by

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The success or failure of ambitious schemes for economic development is often determined largely by the response of the initially dominant sector, agriculture, to the economic stimuli contained in the development program. Policy-makers are therefore keenly interested in any information that can help them predict the behavior of the farm sector. In providing this sort of information, economists have given the lie to some long-cherished ideas about farmers' behavior. The former picture of the typical peasant as a stubbornly unresponsive, tradition-bound non-maximizer, for example, has had to give way to empirical evidence that his reactions reflects keen awareness of, and very fine adjustment to, economic incentives. In particular, studies of farmers' response to price have shown peasants in many countries with marked differences in income levels to have remarkably similar responses to changes in the relative prices of various crops.[1/]

Typically, such studies choose a country or a particular region for analysis, so that the estimates of price elasticity derived represent a weighted average of the adjustments of all farmers in the area to a price change.[2/] If the operators of different-size farming units have different responses to price, then the elasticity of output (or marketings) will vary according to the distribution of farms by size. This question becomes one of major importance for any land reform which seeks to change the size distribution of operating farm units.

The effect of a change in size distribution on elasticity would probably be most sharply felt in a land reform which aimed to replace large estates with a system of small farms. Any difference in response between latifundistas on the one hand, and small peasants on the other, would be critically important. If, as is unfortunately the normal case, we cannot estimate these differences directly from current data, historical experience can throw some light on this subject. Some countries in which large-estate agriculture was dominant have long series of reasonably reliable data on agricultural production and prices which can be used to estimate whether their response to price differs significantly from that observed in peasant agricultures elsewhere. The present paper focuses on Hungary, with some comparisons to Germany, during the decades immediately prior to the First World War.[3/]

I

The model with which this study starts is that developed by Nerlove[4/] and used in one form or another in all the studies mentioned in footnote 1. The basic premise of the model is that output in any period is a function of the expected normal price of that period (since farmers must plant their crops before knowing exactly what the actual price will be). This may be formally stated in linear form as

$$Q_t^A = a_o + a_1 P_t^E + u_t \qquad (1)$$

in which a_o is a constant, P^E is the expected price, and u a random residual term.

Farmers are further assumed to revise their price expectations in light of actual experience. Thus the expected normal price (ENP) at any time, t, would be the ENP of the previous period plus a correction factor. Take this correction factor as some fraction,

β_1, of the difference between last period's ENP and the actual price (P^A) observed last period, i.e.

$$P^E_t = P^E_{t-1} + \beta_1 \left(P^A_{t-1} - P^E_{t-1}\right) \tag{2}$$

The general solution of such a difference equation is (ignoring the constant term)

$$P^E_t = \sum_{\lambda=o}^{t} \beta(1-\beta_1)^{t-\lambda} \cdot P^A_{t-\lambda} \tag{3}$$

This is a standard distributed-lag structure, in which past price observations are the basis of the current expectation, but whose importance in determining the level of current expectation declines as one proceeds further into the past. Such a structure seems intuitively reasonable, even though the choice of this over any other declining-weight structure is arbitrary.

From the basic model, equations (1) and (2), we can derive a single reduced-form estimating equation[5/]

$$Q^A_t = a_o\beta_1 + a_1\beta_1 P^A_{t-1} + (1-\beta_1)\, Q^A_{t-1} + v_t \tag{4}$$

in which $v_t = u_t - (1-\beta)u_{t-1}$. Assumptions are usually made about the form of v_t in order to justify the use of ordinary least squares for estimation of the coefficients.[6/]

One very important characteristic of the Nerlove model is that even though it postulates output to be a function of expected price, and expected price to be a function of all past observed prices, the actual estimating equation (4) requires only one actual observed price for each observation on the dependent variable, output. Thus the data requirements are very much less formidable than might first appear.

There is an alternative interpretation of equation (4) which arises when one assumes an "adjustment" model instead of an "expectations" model. The adjustment model postulates that desired output, Q^D, is a function of last period's actual price, i.e.,

$$Q_t^D = b_o + b_1 P_{t-1}^A + u_t \tag{5}$$

and that this period's actual output will equal last period's output plus an adjustment. The adjustment is some fraction, β_2, of the difference between the desired output this period and the actual output achieved last period. Formally, this can be written as

$$Q_t^A = Q_{t-1}^A + \beta_2 (Q_t^D - Q_{t-1}^A) \tag{6}$$

Except for a small difference in the form of the residual term,[7/] the estimating equation derived from this model is exactly of the same form as that derived from the first, or expectations, model, i.e.,

$$Q_t^A = b_o \beta_2 + b_1\beta_2 P_{t-1}^A + (1-\beta_2) Q_{t-1}^A + v_t \qquad (7)$$

where $v_t = \beta_2 u_t$

The adjustment model is the more often used, most particularly because it has the econometric advantage of not adding as many extra terms to the estimating equation when other independent variables (e.g., yields per unit of land) are included in the underlying equations.[8/] The two models could be combined by taking the obvious step of making desired quantity a function of expected price, but this is a move which involves some ambiguities.[9/]

One further modification is usually made before testing the model against the data. Since output equals yield times acreage, and because yields are subject to large random fluctuations caused by weather as well as errors of estimation, most studies of price response use acreage rather than output as the dependent variable. If yield per acre itself has some price elasticity (as when higher crop prices induce farmers to use more labor and other inputs on their land), the estimated elasticity of acreage with respect to price will represent a lower bound to the output elasticity measurement. For the above reasons, and also for greater comparability to other work, this study will also use the area (expressed in hectares) devoted to each included crop as the dependent variable.

II

This study will focus on the supply of the five major grains -- wheat, rye, barley, oats, and corn -- of Hungary between 1870 and 1913.[10/] Growth of output of these five grains measured an average of 2.5% per annum from 1870/74 to 1909/13, a figure which probably overstates the "true" growth rate by about one-half point because of the generally bad harvests of the 'seventies.[11/] The price response will be compared to that of Germany for four of the five crops (data for corn, a very minor crop in Germany, were not reported for the period under review). For Germany, however, the analysis must be confined to the period 1893-1913, because of data problems.[12/]

The money prices of the five major grains generally fell from the 'seventies until early 'nineties, and then began to rise again. The price decline corresponded very closely to the "invasion" of the European wheat market by large shipments of North and South American, as well as Russian and Australian wheat. The rising trend is a result both of a favorable movement in agricultural terms of trade in the world as a whole, and of Austro-Hungarian tariffs against foreign grain. Each of the grain prices reached its low point in 1893 (plus or minus two years), which was accordingly chosen as a dividing point to test the hypothesis that the response was different during the decline from that during the rise in prices.

The first step of the analysis is to estimate equation (4) or (7) in its simplest form, without the introduction of any shifter variables or other modifications. Since the acreage data begin with 1870, 1871 must be the beginning year for the regression equations because of the inclusion of acreage (actually hectarage) lagged one year as an independent variable. The raw prices of each crop, expressed in crowns per quintal, are deflated by an index of the prices of the other four crops.[13/] This deflator is based on average 1891-95 prices and uses average quantities for the same five years as weights.[14/]

It would have been preferable to use a more general deflator which included the prices of everything (or at least every important thing) which competed with the crop in question for the use of land. This was not possible simply because the necessary prices are unavailable. Only the prices of the five grains are available back to 1870, so it is only they which can be included. Exclusion of other prices is not quite so serious as it may first appear, since the five crops under consideration accounted for four-fifths of all crop and pasture land in Hungary during the period under review.[15]

Lags of both one and two years in the price variable were tried in the estimation, on the ground that for some crops (particularly those primarily fall-sown, such as wheat and rye) all the prices of year t-1 are not yet observed by the time the planting decision must be made. Hence the year t-2 may actually be more important. Since the difference between a one-year and a two-year lag is of little consequence for this paper, that equation using the lag which gave the more significant price coefficient was in each case included in

Table 1, which presents the results of the first set of regressions for the elasticity of area response (hectares) with respect to deflated price. The equations were estimated in both linear and logarithmic form. Virtually no differences exist between the two estimates; the log form is therefore presented because the coefficient of the price variable is a direct estimate of the elasticity.

From Table 1, considering only the overall period 1871-1913, we can see that the fit of the equation form, as measured by the levels of R^2, is quite good (except for the case of oats), and that the price coefficient is significant at the 15% level or better for all crops except corn. Although the observed short-run elasticities are low (on the order of 0.1), it should be remembered that these price coefficients are the product of the (long-run) price coefficient from the original equation -- either (1) or (5) -- and the coefficient of expectation, β_1, or the coefficient of adjustment, β_2, depending on which interpretation of the model is used. Thus the calculated elasticity is less than the elasticity of observed acreage with respect to expected price (or of desired acreage with respect to observed price). Since, furthermore, the

Estimation of the Equation $\ln H_t = K + A \ln H_{t-1} + B \ln P_{t-i}$

Crop	Country, lag	Period	R^2	K	A[a]	B	Signif. level of B
Wheat	Hungary i = 1	1871-1913	.92	.55	.96	.12	5%
	Hungary i = 2*	1871-1893	.94	-.011	1.0	.06	-
	Hungary i = 2*	1893-1913	.23	4.4	.47	.08	20%
	Germany i = 2	1893-1913	.26	6.6	-.16[b]	.42	2.5%
Rye	Hungary i = 2[b]	1871-1913	.69	1.4	.83	.11	10%
	Hungary i = 2	1871-1893	.65	1.8	.82	.25	2.5%
	Hungary i = 1*	1893-1913	.29	5.0	.33	.17	10%
	Germany i = 1*	1893-1913	.35	2.5	.65	.11	10%
Barley	Hungary i = 1	1871-1913	.67	2.3	.69	.10	10%
	Hungary i = 1	1871-1893	.76	3.6	.54	.19	2.5%
	Hungary i = 1*	1893-1913	.35	3.0	.65	.04	-
	Germany i = 2	1893-1913	.24	.19	.04[b]	.27	2.5%
Oats	Hungary i = 2	1871-1913	.43	2.2	.70	.05	15%
	Hungary i = 2	1871-1893	.46	3.2	.57	.11	2.5%
	Hungary i = 2*	1893-1913	.45	1.5	.67	.11	-
	Germany i = 2*	1893-1913	.63	1.3	.81	.05	-
Corn	Hungary i = 1*	1871-1913	.90	.58	.93	.01	-
	Hungary i = 2*	1871-1893	.86	1.0	.88	.05	-
	Hungary i = 2*	1893-1913	.58	1.6	.79	.01	-
	Germany N.A.	---	--	--	--	--	N.A.

a/All coefficients significant at 5% level or better, except as noted.

b/Not significant, even at 20% level.

* No significant difference in fit of equations nor in significance of price coefficient using either i = 1 or i = 2.

adjustment or expectations coefficient -- which is equal to (1-A) -- has a maximum value of only 0.31 (barley), the overall impression must be one of rather inflexible response to price change. We shall return later (section III) to a further consideration of this point.

When considering the two subperiods for Hungary, the changes observed are quite startling. For each crop, the "fit" (again as measured by the value of R^2) falls off markedly from the first to the second period. The measured elasticities change very little, however, except for the case of barley. For wheat and rye, the β-coefficient rises sharply (as measured by a fall in A), whereas for barley, oats, and corn it changes less dramatically.

In the German case, it is interesting to note that for the minor crops, wheat and barley, the adjustment coefficient derived from the estimate of A is unity, so that the measured short-run elasticity is, by implication, also the long-run elasticity. For Germany's pre-eminent grain crop, rye, the measured elasticity is in the same range as those observed for all grains in Hungary. When comparing the implied long-run elasticity in the 1893-1913 period with that for Hungary's dominant crop, wheat, we find the two nearly equal; moreover, this equality carries through to both components, the adjustment (or expectations) coefficient and the measured short-run price elasticity.

Although the measured elasticities are generally low, it should be noted that they are not uniformly lower than those observed by other studies for grain crops grown in peasant agricultures. The short-run elasticity of corn acreage with respect to price was estimated at 0.23 for the Punjab region of India-Pakistan,[16/] and 0.07 for the Philippines;[17/] for rice there have been observations of no observable elasticity (Philippines),[18/] 0.12 (East Pakistan),[19/] 0.30 (Indonesia),[20/] and 0.31 (India-Pakistan)[21/] and for wheat, 0.08 in the Punjab[22/] and 0.20 for irrigated acreage in West Pakistan.[23/] The few estimates of price response in estate-grown crops also do not show lower elasticities than those observed in Hungary or Germany. Malayan rubber estates exhibited nearly zero price elasticity,[24/] while a study of sugarcane in the Philippines (often grown on larger estates) estimated the price elasticity of supply response at zero.[25/]

In any case, an inelastic supply response does not necessarily connote the absence of profit-maximizing behavior on the part of producers. Too elastic an increase in output may actually cut profits, if the demand curve facing the producers is inelastic. Since such demand curves are the norm for most agricultural products within any given country or region, farmers might be expected soon to learn that large responses to price changes are self-defeating. In an agriculture such as Hungary's or Germany's, dominated by a relatively few great landholders, the recognition of the mutual benefits of restricting the output increase when prices are subject to upward pressure from demand within a protected market might be rather easily made and communicated. When the landlords comprise a hereditary nobility with strong social pressures against behavior inimical to the interests of the class, monopolistic practices are relatively easy to enforce, even if they work against the immediate economic interest of an individual member of the aristocracy.

The behavior differences observed for Hungary between the first and second periods are consistent with Prof. Jászi's claim that from about 1890 onwards the

Hungarian grain farmers turned from an emphasis on increasing production and began instead to exploit their near-monopoly position within the protected market of the Austrian Empire by holding production rather steady, letting growing demand push prices up.[26/] The implied increase of the adjustment coefficient, β_2, is not necessarily inconsistent with this hypothesis, since it could indicate that within an overall strategy of limiting grain production, the producers still adjusted the composition of their output to reflect changing patterns of demand.

III

Considering the relatively low values of the adjustment (or expectations) coefficient in Table 1 ($\beta = 1-A$), and that the estimated elasticity is the product of this coefficient and the "true" price coefficient, it is not surprising to find measured elasticities near zero. While such a result may be an accurate representation of producers' behavior, it may also arise merely from an inherent weakness of the model iteself: If there is a long-run trend in the output variable--caused, for example, by favorable movements in agriculture's terms of trade or by cost reductions in production--the deflated price variable may not capture much of this trend if grain prices tend to move together. The two sources of difficulty in this case--the appearance of lagged acreage as an independent variable and the incomplete nature of the price deflators (they contain no correction for terms of trade or cost of production changes) -- tend to reinforce each other. Thus an alternative formulation of the model might be desirable.

Lacking any data on the general price level, or even on agricultural prices in general, we cannot deal directly with the deflation problem, yet there are some ways of dealing with the first problem which promise to get around some of the difficulty with the price variable as well. One such change is a very simple one: merely substitute the lagged total acreage for the group of crops considered (call it Z, after Krishna) for the lagged acreage of the crop in question in the estimating equation, to give

$$H_t^A = C_1 + C_2 P_{t-1}^A + C_3 Z_{t-1} + w_t \qquad (8)$$

where w is a residual term.

If there is a trend in acreage which represents, for example, a terms of trade change or a production cost change that applies to the group as a whole, the variable Z should account for most or all of it, leaving changes in H (the hectarage) which are greater or less than that expected from the trend to be explained by changes in relative prices among the group. Table 2 presents the results of this estimation procedure.

The striking difference between the two periods is again evident, as is the weakness of the price variable in explaining variations in the acreage. Besides the generally poor results from this estimation, the procedure has the disadvantage of masking entirely the magnitude of β_1 or β_2.

A different approach which does not suffer from this defect is to use deviation from trend as the dependent variable. This has the further advantage of not binding each crop's trend to the trend in Z, and gives an estimating equation of the form

$$(H^A-H^T)_t = d_1 + d_2P^A_{t-1} + d_3(H^A-H^T)_{t-1} + s_t \qquad (9)$$

in which H^T is the estimate of hectares planted to the

Table 2

Estimation of the Equation

$$\mathrm{lm}\, H_t = C_1 + C_2 \mathrm{lm} P^A_{t-i} + C_3 \mathrm{lm} Z_{t-1}$$

(Hungary only)

Crop	lag	Period	R^2	C_1	C_2	T_{C_2}		C_3	T_{C_3}
heat	i=2	1871-1893	.89	-7.9	-1.3	---	--	-1.7	9.9
	i=2	1893-1913	.29	2.3	.07	.81	--	.66	2.6
ye	i=2	1871-1893	.41	13.3	.24	1.55	10%	- .64	-3.7
	i=2	1893-1913	.19	6.9	.23	1.99	5%	.05	.26
arley	i=1	1871-1893	.82	1.4	.09	1.1	15%	.64	5.5
	i=1	1893-1913	.60	-2.0	- .06	- .624	--	.97	5.0
ats	i=2	1871-1893	.10	-7.3	.09	1.5	10%	- .018	- .135 -
	i=2	1893-1913	.62	-1.9	.00	----	--	.977	5.35
orn	i=2	1871-1893	.88	-4.6	- .04	-.5	--	1.35	11.7
	i=2	1893-1913	.51	-3.3	- .07	-.882	--	1.2	4.35

crop in question from an equation relating hectares to time alone, (i.e., the estimated value of H from a simple trend), and s_t is the residual. The coefficient d_3 from equation (9) is a better estimate of $(1-\beta_1)$ or $(1-\beta_2)$ than the corresponding coefficient derived from (4) or (7) if a trend which is caused by something external to the model exists and is not captured in the price variable.[27/]

The estimates of (9) are recorded in Table 3. If we consider the adjustment model, then the adjustment coefficients (β_2) implied by the d_3 coefficients from the table fall into the following ranges:

1871-1893:	0.73 (oats) to 0.37 (corn)
1893-1913:	0.75 (corn) to 0.71 (barley)
1871-1913:	0.61 (barley) to 0.31 (oats)

Such a range seems much more reasonable a priori than the range of 0.46 to zero implied in the results from Table 1. Again, the data from the second period fit the hypothesis much less well, even though the implied adjustment coefficients are somewhat higher. And again a significant price response is not the norm.

TABLE 3

Estimation of the Equation
$$(H^A-H^T)_t = d_1 + d_2P^A_{t-1} + d_3(H^A-H^T)_{t-1}$$

Crop, lng	Period	d_1	d_2	signif. level of d_2	d_3	signif. level of d_3	R^2
Wheat i=1	1871-1913	-212	11.6	---	-.675	0.5%	.246
	1871-1893	-69	3.92	---	0.368	10%	.129
	1893-1913	-157	908	---	0.162	---	.030
Rye i=2	1871-1913	-126	9.63	10%	0.536	0.05%	.309
	1871-1893	-308	23.7	2.5%	0.616	0.05%	.374
	1893-1913	-138	-10.3	15%	0.278	15%	.177
Barley i=1	1871-1913	-63	5.69	15%	0.389	0.05%	.223
	1871-1893	-34	3.34	---	0.267	10%	.132
	1893-1913	-62	6.47	---	0.288	15%	.117
Oats i=2	1871-1913	-51	4.55	15%	0.694	0.05%	.423
	1871-1893	-122	10.8	1%	0.542	0.5%	.504
	1893-1913	-5	47.1	---	0.153	---	.027
Corn i=1	1871-1913	45	-3.17	---	0.463	0.5%	.229
	1871-1893	57	-5.17	---	0.633	0.5%	.455
	1893-1913	28	-219	---	-.245	15%	.070

Numerous other alternative formulations were tried as well,[28/] with the same pattern of results: generally rather inelastic price response, and a marked change in observed behavior between the first and later subperiods.

IV

All the estimates so far presented have used countrywide data only. Regional statistics are available for the seven major regions of Hungary proper beginning with 1891. The regions will be referred to by number; these are the following (with an English translation of the official Hungarian regional designation):

1. Left Bank of the Danube
2. Right Bank of the Danube
3. Between Danube and Tisza
4. Right Bank of the Tisza
5. Left Bank of the Tisza
6. Tisza-Maros Angle
7. Transylvania

In this breakdown, regions 1, 4, and 7 are mostly hilly and mountainous terrain, region 2 includes the "Little Hungarian Plain" and some more hilly areas, especially in its southern section; and the Great Hungarian Plain (Nagy Alföld) begins across the Danube and spreads out over regions 3, 5, and 6.

The data on agricultural land and output were published regionally since 1891, (when the first country-wide survey was made to verify the reports of the county reporters), so that the inclusion of H_{t-1} in the equation to be estimated sets the beginning date at 1892. There are unfortunately no wholesale prices available by regions, but there are series running up to 1910 for retail prices of the five principal grains in the markets of the major towns in Hungary. These are used as the price variable, on the working assumption of proportionality between the wholesale and retail price. Because P is lagged a year, our equation can run to 1911. Where prices from two towns in the same region were available, their mean was used; otherwise the price is that of the single available market series for the region. The regressions were run, as before, using both a one- and a two-year lag for the price variable. Rather than tabulate in excruciating detail all 70 of these, I have adopted an arbitrary selection criterion: to be included in Table 4, the equation must have either a t-value for the price coefficient >1, or an R^2 corrected for degrees of freedom >0.25. Though this seems a liberal criterion for inclusion, it serves to eliminate many of the equations. Since in all cases the equation using a one-year lag in the price variable was superior on these grounds to that using a two-year lag, only the former appear in the table, even though (of course) some of the equations containing P_{t-2} meet the inclusion criterion.

In 1897 a series of harvest strikes took place, seriously affecting the amount of grain harvested and hence the price in some localities. Because this is likely to throw the estimates considerably off in those areas, the observation for 1897 was dropped from all the regions (leaving P_{t-1} and H_{t-1} for 1898 as the 1896 observations on these variables). So the series from which the equation is estimated runs from 1892 to 1911, but includes 19, rather than 20, observations.

Table 4, on the basis of the criterion mentioned above, contains the results for 23 of the 35 possible equations. The first thing to strike one about this table

TABLE 4

Estimation of the Equation

$H_t = K + a_1 H_{t-1} + a_2 P_{t-1}$

Regional Data

1892 - 1911[a]

op	Region	K	a_1	T-value	a_2	T-value	Elasticity[b]	Signif. level of a_2
eat	4	10.3	.832	8.42	1.80	1.78	.134	5%
	5	130	.754	5.36	-.435	-.153	---	---
	7	50.3	.769	5.07	1.82	1.54	.085	10%
e	1	-2.05	.685	4.38	3.56	2.17	.323	2.5%
	2	118	.432	1.93	4.21	1.64	.184	10%
	3	125	.490	3.64	-.954	-.556	---	---
	4	-17.4	.676	5.52	4.07	3.37	.472	0.5%
	5	37.7	.506	2.62	3.83	2.02	.273	5%
	6	-7.39	.636	4.18	1.29	2.73	.688	1%
	7	-37.2	.920	9.54	3.52	2.91	.517	1%
rley	1	61.4	.753	3.71	.594	.283	---	---
	3	54.4	.782	4.84	-1.17	-.568	---	---
	5	65.8	.573	2.87	-2.31	-1.30	---	---
	6	26.0	.649	7.98	-.600	-1.12	---	---
	7	4.53	.919	7.07	.083	.335	---	---
ts	2	24.3	.949	7.64	-1.13	-1.24	---	---
	3	42.8	.801	5.01	-.436	-.433	---	---
	5	3.63	.955	6.15	.212	.236	---	---
	6	36.4	.720	4.65	-.720	-.554	---	---
	7	15.2	.882	6.98	.409	.391	---	---
rn	1	14.9	.723	3.61	.118	.232	---	---
	2	27.1	1.02	11.2	-2.52	-2.17	---	---
	3	12.9	.945	9.42	1.90	.707	---	---

a/ Excluding 1897 (see text).

b/ Elasticity of H_t with respect to P_{t-1}.

c/ i.e., R^2 corrected for degrees of freedom ($\bar{R}^2 = 16/19 \cdot R^2$)

H in thousand hectares, P in crowns per quintal.

is that for barley, oats, and corn the price coefficient is either insignificant or of the wrong sign in every case. Again this corresponds to generally high values for β_1 or β_2, so without further probing we cannot be sure whether we can attach any meaning to such a result, especially since the price variable may be seriously deficient.

We find for wheat two cases out of seven in which the price coefficient is significant at the ten percent level or better, and for rye this happens in six of the seven regions, with generally quite high elasticities of observed acreage with respect to price. For three of the regions the implied adjustment coefficient, β_2^* is estimated at what I would consider a more "reasonable" level, i.e., on the order of 0.5.

Again our model seems to do better for a crop which exhibits only a small trend up or down in its acreage. And again, as with the countrywide data, several modified forms of the original model were tested, giving no significant change in the results, with one major exception.

Falcon[29/] suggested a very simple method for testing whether the deflation procedure marks the price response: merely include the prices of all the competing crops undeflated. This will almost certainly introduce problems of multicollinearity, and is very costly in degrees of freedom -- a most relevant consideration when using series as short as those available here for regional estimates. A preferable procedure then might be to make a single index of the prices of the competing crops and introduce this along with the undeflated price of the particular crop in question. Estimation of such a model also gives some idea (albeit a crude one) of cross-elasticities of supply of various crops.

For the countrywide data, the estimation of an equation in which the share of a certain crop in the total acreage devoted to the group (i.e., H/Z) is a function of the price, an estimation using own price (undeflated) and the index of prices of competing crops (undeflated) gave no better results than those using just the single deflated price. When the same procedure was applied to the regional data, a rather different picture emerged. Where before a measurable price response was a rarity, it now became pervasive (see Table 5). In most cases the pattern of signs is what one would expect, i.e., own price coefficient positive and coefficient of price of other crops negative, although for corn this is not the case for any region. The explanation is probably to be found in the customary rotation of crops in Hungary: corn entered much more often than other crops into the rotations with wheat and thus corn plantings tended to follow wheat plantings somewhat; moreover, the price of wheat typically carries a weight of about one-half in the price index of other crops as it applies to corn, so the positive reaction of corn acreage to the price index of the other four grains is not surprising. This sort of reaction could also account for much of the apparent insensitivity of corn acreage to price which characterized all of the previous estimations. A similar explanation probably holds for those cases of apparent positive cross-elasticity and/or negative own-price elasticity observed for barley in regions 5 and 7, and for oats in region 7. Why this perverse type of reaction should appear to be the case for wheat in region 5 - one of the principal wheat growing areas of the country - remains a mystery, however.

TABLE 5

Estimation of the Equation $(X/Z)_t = B + \alpha_1 P_{t-2} + \alpha_2 (PIO)_{t-2}$

Regional data, 1892-1911[a]

	Region	B	α_1	T-value	Elasticity[b]	α_2	T-value	Elasticity[b]	R^2
W	1	32.5	.191	1.19	.132	-9.36	-1.91	-.387	.213
H	2	41.2	.062	.840	.030	-6.03	-3.13	-.179	.545
E	3	46.8	-.019	-.168	-.008	-5.88	-2.00	-.153	.365
A	4	30.9	.432	1.79	.227	-5.20	- .747	-.166	.234
T	5[c]	32.7	-.222	-1.25	-.100	8.89	1.84	.248	.176
	6	58.5	.054	.389	.018	-7.93	-2.70	-.169	.373
	7	31.6	.086	1.19	.044	- .180	- .120	-.006	.134
R	1	24.0	.549	2.49	.444	-12.7	-3.52	-.744	.457
Y	2[c]	19.4	.240	2.21	.180	- 3.27	-2.10	-.184	.237
E	3	13.6	.049	.624	.052	- 1.62	-1.58	-.140	.243
	4[d]	20.4	.570	2.00	.492	-11.1	-2.54	-.732	.294
	5[d]	13.9	.289	2.02	.288	- 3.97	-2.10	-.328	.220
	6	1.70	.118	2.47	1.07	- 1.61	-3.12	-1.23	.388
	7[d]	15.0	.416	1.87	.691	-11.2	-3.90	-1.59	.585
B	1	21.0	1.23	3.63	.469	- 3.02	-1.20	- .099	.543
A	2	17.4	.033	.246	.026	- 1.46	-1.24	- .097	.185
R	3[c]	9.72	-.059	-.439	-.071	1.35	1.16	.142	.148
L	4	19.3	.205	1.25	.136	- 2.40	-1.65	- .135	.147
E	5	8.05	-.282	-1.72	-.427	2.63	1.86	.375	.179
Y	6	no discernible relation							
	7	2.43	.069	3.97	.133	1.57	3.11	.359	.742

TABLE 5
(cont'd)

	Region	B	α_1	T-value	Elasticity[b]	α_2	T-value	Elasticity[b]	R^2
O	1	no discernible relation							
A	2[d]	8.85	.151	3.00	.184	.281	.609	.027	.658
T	3	10.4	.101	1.85	.129	-1.08	-2.56	-.110	.293
S	4	25.0	-.039	-.379	-.023	-2.23	-2.57	-.110	.527
	5[d]	8.42	.081	1.01	.111	- .138	- .211	-.016	.119
	6	4.24	.174	1.37	.323	.284	.314	.047	.302
	7	11.9	-.030	-.358	-.023	2.82	3.26	.214	.495
C	1[d]	4.82	.022	.365	.039	1.78	2.41	.277	.480
O	2	12.9	.224	1.78	.163	1.44	1.06	.090	.414
R	3	19.1	.376	2.15	.165	2.41	1.34	.101	.470
N	4	7.37	.106	1.27	.146	.482	.554	.057	.212
	5[c]	34.6	-.377	-1.72	-.140	.858	.461	.031	.164
	6	31.2	.546	2.02	.154	.202	.089	.006	.278
	7	no discernible relation							

[a] Excluding 1897 (see text).

[b] Elasticity of share of acreage, calculated at the point of means.

[c] Relation estimated for t-1; estimate for t-2 showed no discernible relation between the share and the price variables.

[d] Relation estimated for t-1; estimate for t-2 gave slightly smaller values of t for the price coefficients, but differences were not statistically significant.

The data contained in Table 5 seem to show a rather general pattern of price responsiveness in the allocation of land among the various grains. Further, it would appear to be the case that were the model complex enough to take into account standard rotation practices, this responsiveness would stand in yet sharper relief: those cases of seemingly positive cross-elasticity of supply in the short run hint at this, and the existence of positive coefficients for both own price and price of others indicated a multi-collinearity in the observations on the independent variables which could serve to cover up the "true" level of significance of prices in the allocation decision. The generally better results using a two-year lag may also be due to the problem of rotations - once a winter crop is sown, a spring crop cannot be planted on that same ground until the next following year. This would not bind the choice of which spring crop to the price of two years ago, but such considerations no doubt strongly influence the choice as between winter and spring crops as groups. Insofar as their prices tend to move together, this might be sufficient to account for the greater apparent power of the prices lagged two years in explaining changes in the allocation of grain land.

IV

The observed price response in all formulations of the basic model, as well as in most of the alternatives attempted, has either been small or apparently non-existent. This implies either (a) that price was not very important in the acreage decisions of Hungarian grain farmers, or (b) that while important, price was overwhelmed by some other consideration, or (c) that price expectations and the responses thereto were formed in a manner quite different from that postulated in the models used.

A test of proposition (b) might be in order, since during the period under review such a potentially dominant factor was present, namely the great expansion of the Hungarian railway network. From the 2700 kilometers extant in 1868, the length of line increased to 22,000 km. by the end of 1913.[30/] The expansion of the market made possible by the extension of the transportation network may have been of crucial importance for Hungary, just as Myint suggests it was for many other economies.[31/] To test this proposition, I have postulated an equation in which the amount of land devoted to a given crop in a given year is a function of the deflated price and the length of railroad line in place at the end of the preceding year. The results of this estimation are presented in Table 6.

The first striking feature of this formulation is the importance of the railroad variable in explaining changes in acreage - it is significant at the 2.5 percent level or higher for 12 of the 15 cases tabulated, and at ten percent or better for two of the remaining three. The observed negative elasticity of rye acreage with respect to railroad mileage results from the status of rye as an inferior good - in particular as an inferior substitute for wheat in bread-making. Why oats should also exhibit this apparent negative elasticity in the early period is less clear. Perhaps with a relatively constant horse population and with increasing yields per hectare, fewer acres of oats were needed to provide the requisite amount of feed.

It is also interesting to compare the results of the estimation of this "railroad" model with those of the basic model. In Table 7 I have collected the estimations of acreage elasticity with respect to price and the level of R^2 for the basic models and the railroad

TABLE 6

Estimation of the Equation

$L_nH_t = C + b_1 \ln P_{t-1} + b_2 \ln RR_{t-1}$

Crop	lag	Period	C	b_1	signif. level of b_1	b_2	signif. level of b_2	R^2
Wheat	i=1	1872-1913	5.34	-.100	10%	0.312	0.05%	.90
		1872-1893	3.73	.018	---	0.456	0.05%	.96
		1893-1913	6.58	-.039	---	0.167	2.5%	.23
Rye	i=2	1872-1913	7.82	0.137	10%	-0.126	0.05%	.65
		1872-1893	7.80	0.281	5%	-0.164	0.05%	.45
		1893-1913	7.26	0.170	10%	-0.076	10%	.27
Barley	i=1	1872-1913	5.68	0.150	2.5%	0.093	0.05%	.61
		1872-1913	5.39	0.138	10%	0.130	0.05%	.75
		1893-1913	4.78	0.112	---	0.195	0.5%	.34
Oats	i=2	1872-1913	6.95	0.034	---	-0.012	---	.01
		1872-1893	7.07	0.138	2.5%	-0.053	5%	.28
		1893-1913	4.57	-0.027	---	0.249	0.05%	.55
Corn	i=2	1872-1913	5.35	-0.050	15%	0.256	0.05%	.89
		1872-1893	5.51	-0.178	0.5%	0.271	0.05%	.90
		1893-1913	4.34	-0.011	---	0.349	0.05%	.62

RR = kilometers of railroad in place in Hungary at year's end.

Table 7

Observed Elasticities[a] and R^2 from Basic Model and from "Railroad" Model

1871(2) - 1893

Crop	Period	E_B	E_{RR}	R^2_B	R^2_{RR}
Wheat	1871(2)-1913	.12	---	.905	.908
	1871(2)-1893	---	---	.941	.965
	1893-1913	---	---	.229	.230
Rye	1871(2)-1913	.11	.14	.695	.652
	1871(2)-1893	.25	.28	.655	.452
	1893-1913	.17	.17	.286	.273
Barley	1871(2)-1913	.10	.15	.669	.618
	1871(2)-1893	.19	.14	.760	.755
	1893-1913	---	---	.355	.348
Oats	1871(2)-1913	.05	---	.408	.618
	1871(2)-1893	.11	.14	.460	.288
	1893-1913	---	---	.455	.550
Corn	1871(2)-1913	---	---	.896	.897
	1871(2)-1893	---	negative	.861	.907
	1893-1913	---	---	.583	.623

[a] Elasticity of observed acreage with respect to observed price. Quantity entered if price coefficient was significantly different from zero at the 15 percent level.

Source: Tables 1 and 6.

model for each of the three time periods considered. What is immediately evident is that the basic (Nerlove-type) model has no real superiority over the simple formulation which relates acreage to price changes and expansions of the transportation network in explaining the supply behavior of Hungarian grain farmers for the period under investigation. Because the number of kilometers of railway in place is a good proxy for time, the "railroad" model may not have revealed very much. Unfortunately it was not possible to obtain an annual series for length of the rail network by regions, which could have made possible a much better test of the expanding-market-through-transportation-expansion hypothesis.

Where then has all this brought us? It seems reasonable to conclude from all of the foregoing estimates that although some responsiveness to price did exist, it was a rather inelastic response, though neither more inelastic than that observed for several peasant economies of today nor that for the United States (as reported by Nerlove).[32/] Every alternative which allowed the division of time series in the mid-1890's exhibited a marked fall-off in its explanatory power when applied to the second period.

Price responses tended to become more inelastic or to disappear from the estimates after 1893, although some of the regional estimates still show a fairly pervasive, if inelastic, price response. This apparent reduction in the flexibility of Hungarian agriculture occurred along with an increase in tariff protection around the Empire,[33/] and an increase in the share of large estates in the land distribution. Thus we cannot reject the hypothesis that the expansion of the large-estate sector did not make Hungarian agriculture less price-responsive.

This does not mean, however, that the Hungarian farmers did not respond to economic incentives. The apparently rather strong response to the expansion of the railroad network is an illustration of this point. The fall-off in price responsiveness in the latter part of the period can also be consistent with profit-maximizing behavior. As noted earlier, farmers faced with an inelastic demand curve for their products may learn very quickly that too strong a reaction to price change earns them nothing. As the market for Hungarian grains shrank geographically and became ever more exclusively a "domestic" - i.e., Austro-Hungarian Empire - market, we would expect that the elasticity of demand facing Hungarian grain producers would also have shrunk, especially with the import of available substitutes (i.e., foreign grains) increasingly restricted by tariffs. The data are consistent with, though do not prove, monopoly behavior.

Thus, with evidence available, we cannot conclude with certainty that Hungarian agriculture was more or less responsive to economic incentives, or more or less intent on profit maximizing, that the agricultures of other countries and times studied by other researchers. Such evidence as can be found seems to indicate, however, that there is no compelling cause to assume Hungary's responsiveness to be very much different either from that of currently underdeveloped countries, despite the differences in the structure of landownership, or from that of Germany, with a similar land distribution.

F O O T N O T E S :

1/ The literature is quite extensive. See for example P. T. Bauer and B. S. Yamey, "A Case Study of Response to Price in an Under-developed Country," Economic Journal, LXIX (December, 1959), 800-805; Robert M. Stern, "The Price Responsiveness of Egyptian Cotton Producers," Kyklos, XII (1959), 375-84, and "The Price Responsiveness of Primary Producers," Review of Economics and Statistics, XLIV (May, 1962), 202-207; Raj Krishna, "Farm-Supply Response in India-Pakistan: A Case Study of the Punjab Region," Economic Journal, LXXIII (September, 1963), 477-487; Walter P. Falcon, "Farmer Response to Price in a Subsistence Economy: The Case of West Pakistan," American Economic Review, LIV (May, 1964), 580-591; or M. J. Bateman, "Aggregate and Regional Supply Functions for Ghanaian Cocoa," Journal of Farm Economics, XLVII (May, 1965), 384-401.

2/ One study which makes a specific distinction between the response of estate-owners and that of small-holders is Clifton R. Wharton, Jr. "Malayan Rubber Supply Conditions," in The Political Economy of Independent Malaya, ed. T. H. Silcock (Canberra: Australian National University, 1963), 131-62.

3/ Hungary was perhaps an archetypical example of the latifundia system, and the share of these enormous properties in the total land distribution increased during the period under review, so that by 1914 estates of 1400 acres or larger included more than 40% of all landed property. See S. M. Eddie, "The Changing Pattern of Land-ownership in Hungary, 1867-1914," Economic History Review, XX (August, 1967), 296. For comparisons of land distribution with Germany and other European countries, see ibid., 301-03.

4/ Marc Nerlove, The Dynamics of Supply: Estimation of Farmers' Response to Price (Baltimore: Johns Hopkins Press, 1958).

5/ For a proof of the derivation, see ibid., 25-26, 62-65.

6/ Ordinary least squares estimation will not give unbiased estimates of the parameters in the case of serially-correlated residuals. In the present paper, a two-stage least-squares estimation procedure -- which avoids this problem -- was tried, but the results were indistinguishable from those resulting from the use of ordinary least squares. Another approach to this problem would be to use the quadratic hill-climbing technique developed by Goldfeld and associates (S. M. Goldfeld et al., "Maximization by Quadratic Hill-Climbing," Econometrica, XXXIV (July, 1966), 541-551). An application of this technique to price-response estimation can be found in Jere R. Behrman, "The Relevance of Traditional Economic Theory for Understanding Peasant Behavior: A Case Study of Rice Supply Response in Thailand, 1940-1963," paper read at the Econometric Society Meetings, Washington, D.C., December 30, 1967. (This paper has since been included as part of a larger study. See Jere R. Behrman, Supply Response in Underdeveloped Agriculture: A Case Study of Four Major Annual Crops in Thailand, 1937-1963 (Amsterdam: North Holland, 1968).

7/ In this case the residual, $v_t = \beta_2 u_t$. See Nerlove, 26.

8/ Krishna refers to these extra variables as "shifter" variables, and explains the effect on the original model of their inclusion. See Krishna, 478.

9/ The combination would make desired quantity a function of expected price, and use equations (3) and (6) to represent the revision of price expectations and the adjustment of actual acreage, respectively. There is no necessity that the two coefficients β_1 and β_2, be equal. The problem arises, however, that β_1 and β_2 enter absolutely symmetrically into the reduced-form estimating equation, so that a separate value for each cannot be calculated from the parameters estimated. Nerlove suggests a way around this: finding another variable that enters into the equation for expected price, or for acreage adjustment, but not both (Nerlove, 65). For a further

9/cont'd
consideration of this problem, see appendix 1 to this paper.

10/It would perhaps be appropriate to remind the reader that "Hungary" referred to here is not the present small state, but the eastern half of the Austro-Hungarian empire. Pre-World War I Hungary had about 3 times the area and about twice the population of present-day Hungary.

11/For a more detailed discussion of this point, see S. M. Eddie, "Agricultural Production and Output per Worker in Hungary, 1870-1913," Journal of Economic History XX (July, 1968), 200-201.

12/Annual crop surveys were not begun in Germany until 1893. Sharp breaks in the acreage series for the German grain crops occur at each year (e.g., 1878, 1883) when a crop survey was made. The changes in acreage between crop surveys were usually strongly underestimated. Data from Statistisches Jahrbuch für das Deutsche Reich, various issues.

13/Nerlove uses the price of all the crops included in his study in constructing his deflator. Thus "own price" appears in both the numerator and denominator of the expression for deflated price of a given crop -- a procedure which imparts an upward bias to elasticity estimates. Separate deflators for each crop are used in the present paper to avoid this problem.

14/The choice of 1891-95 as the base for the price index requires some explanation, since it was a time of very low prices. Alternative price indices based on 1909-13 were also used, with virtually no detectable difference in the results of any of the regressions. Since the use of 1891-95 prices does not measurably affect any of the estimates, it is more convenient to apply, being a single base that can be applied for both subperiods.

15/ S. M. Eddie, "A Preliminary Econometric Investigation of Supply and Demand Conditions for Hungarian Grain Crops, 1887-1913," unpublished paper (mimeo), Massachusetts Institute of Technology, 1962, chart 1.

16/ Krishna, 483.

17/ Mangahas, Recto, and Ruttan, "Price and Market Relationships for Rice and Corn in the Philippines," Journal of Farm Economics, XLVIII (August, 1966), 685-703.

18/ *Ibid.*

19/ S. M. Hussain, "A Note on Farmer Response to Price in East Pakistan," Pakistan Development Review, IV (Spring, 1964), 102.

20/ Lee Fletcher and Mubyarto, "Supply and Market Surplus Relationships for Rice in Indonesia," paper read at the Agricultural Development Council-University of Minnesota Conference on Supply and Market Relationships in Peasant Agriculture, Minneapolis, February 1966.

21/ Krishna, 483.

22/ *Ibid.*

23/ Walter P. Falcon, "Farmer Response to Price in an Underdeveloped Area: A Case Study of West Pakistan," unpublished Ph.D. dissertation, Harvard University, Department of Economics, 1962, 142.

24/ Wharton.

[25] Edmundo R. Prantilla, "The Supply Response of Sugar in the Philippines," M.S. Thesis, University of the Philippines, 1st Semester 1968-69, 150. The nil figure is misleading, however, since the sugar export quota was the operative constraint. Elasticity of hectarage with respect to size of the quota was near unity.

[26] Oscar Jászi, The Dissolution of the Habsburg Monarchy (Chicago: University of Chicago Press, 1929), 196-200.

[27] The estimating equation (9) is derived in an exactly analogous fashion to equation (7). The proof is contained in appendix 2.

[28] For example, the share of acreage for the group devoted to any given crop (i.e., H/Z) was made a function of price -- recognizing explicitly the allocational nature of the cropping decision assumed. Yields were included, but were nowhere significant. Various lags on the several independent variables were assumed and tried, as was an arbitrary structure of weights in determining the expected normal price. None of these gave any better results than the original model, and exhibited the same general pattern of response.

[29] Falcon, 74-75.

[30] See Magyar Statisztikai Évkönyv (Hungarian Statistical Yearbook), various issues between 1871 and 1914.

[31] Hla Myint, The Economics of the Developing Countries (New York: Praeger, 1965), Ch. 3.

[32] For the period 1909-1932, the observed elasticities of acreage with respect to price were 0.27 for cotton, 0.48 for wheat, and 0.10 for corn. The adjustment coefficients were 0.41, 0.52, and 0.54 respectively. See Nerlove, 201-04.

33/ For a fuller discussion of the tariff history of Austria-Hungary, see S. M. Eddie, "The Role of Agriculture in the Economic Development of Hungary, 1867-1913," unpublished Ph.D. thesis, M.I.T. Department of Economics, 1967, ch. IV. The discussion there relies heavily on two German-language works: Josef Grunzel, Handelspolitik und Ausgleich in Österreich-Ungarn (Vienna and Leipzig: Duncker und Humblodt, 1912) and Alexander von Matlekovits, "Die Handelspolitischen Interessen Ungarns," in Beiträge zur neuesten Handelspolitik Österreichs ("Schriften des Vereins für Socialpolitik," vol. XCIII; Leipzig: 1901).

Appendix 1

Further Considerations of the Basic Model

When we attempt to combine the "expectations" and "adjustment" forms of the basic model by relating desired output to expected price, certain difficulties result. Nerlove (pp. 63-65) demonstrated this by adding such a relation (he assumed it to be proportional for simplicity), e.g.

$$Q_t^D = rP_t^E \tag{i}$$

When combined with an expectations equation,

$$P_t^E = P_{t-1}^E + \beta_1 \left(P_{t-1}^A - P_{t-1}^E\right)$$

and an adjustment relation,

$$Q_t^A = Q_{t-1}^A + \beta_2 \left(Q_t^D - Q_{t-1}^A\right) \tag{ii}$$

would give an estimating equation of the following form:

$$Q_t^A = r\,\beta_1\beta_2\, P_{t-1}^A + \left[(1-\beta_1) + (1-\beta_2)\right] Q_{t-1}^A + (1-\beta_1)(1-\beta_2)Q_{t-2}^A \tag{iii}$$

Because β_1 and β_2 enter symmetrically into the expression (equation iii) for Q_t^A, we cannot isolate them. If they could be made to enter the relation asymmetrically (Nerlove's suggestion was to find some other variable which enters the relation between Q^D and P^E -- see footnote 9), this difficulty could be overcome.

Although it may be impossible to isolate values for β_1 and β_2 unless either or both can be shown a priori to be zero or one, it may still be possible to derive $\underline{r}$, the price coefficient from equation (i). Since the price coefficient is often the principal point of interest in the sorts of problems with which we are here dealing, being able to derive an estimate of $\underline{r}$ may be at least as important as estimating β_1 or β_2.

The derivation of $\underline{r}$ would proceed as follows: Rewrite (iii) as

$$Q_t^A = AP_{t-1} + BQ_{t-1}^A + CQ_{t-2} \quad \text{(iv)}$$

where

$$A = r\beta_1\beta_2 \quad \text{(v)}$$

$$B = 2 - \beta_1 - \beta_2 \quad \text{(vi)}$$

$$C = (1-\beta_1)(1-\beta_2) = 1-\beta_1 - \beta_2 - \beta_1\beta_2 \quad \text{(vii)}$$

From the regression estimating (iv) we would have values for A, B, and C. Combining (vi) and (vii) and rearranging terms, we have $\beta_1 \beta_2 = C - B + 1$. Since we have estimates of B and C, we can calculate $\beta_1 \beta_2$. Substituting the value of $\beta_1 \beta_2$ into (v) allows us to calculate r.

Two problems arise when we attempt to estimate a relation such as (iv). One is the previously-mentioned problem of biased estimates of the coefficients because of the inclusion of lagged values of the dependent variable as independent variables. The other is a problem of multicollinearity: since in most applications the Q's are likely to be highly serially correlated, the values of Q_t^A and Q_{t-1}^A used as independent variables are likely to show a very strong correlation with each other. This is not a problem which can be solved by simple algebraic manipulation of the functions.

Appendix 2

The "Deviations" Model

The "deviations from trend" model produces an estimating equation which is the exact analogue of the estimating equation (7) from the basic model. Let the actual deviation from output trend in period t, $Q_t^A - Q_t^T$, be designated Y_t^A, and the desired deviation of output from trend, $Q_t^D - Q_t^T$, be designated Y_t^D. Then a "deviations" form of the basic model would appear as follows (ignoring residual terms for simplicity):

$$Y_t^A = Y_{t-1}^A + \alpha(Y_t^D - Y_{t-1}^A) \qquad \text{(i)}$$

and

$$Y_t^D = K + sP_{t-1}^A \qquad \text{(ii)}$$

From this the estimating equation (9) follows, with $d_2 = \alpha s$ and $d_3 = (1-\alpha)$, by exactly the same procedure as used to derive equation (4) or equation (7). Note that equation (i) above could be written out as

$$(Q^A - Q^T)_t = (Q^A - Q^T)_{t-1} + \alpha[Q_t^D - Q_t^T - (Q_{t-1}^A - Q_{t-1}^T)] \qquad \text{(iii)}$$

since Y^D, the desired deviation from trend, equals $Q^D - Q^A$.

From the equation for Q^T, i.e.,

$$Q_t^T = C + mT \qquad \text{(iv)}$$

where T is a variable indexing time, we see that as m approaches zero, Q_{t-1}^T approaches Q_t^T. In the limit, with $Q_{t-1}^T = Q_t^T$, equation (iii) reduces to equation (5) in the text, i.e., $\alpha = \beta_2$.

If $m \neq 0$, then $\alpha \neq \beta_2$. But because the estimate of β_2 from equation (7) is biased by external factors for which trend is the proxy, while $\underline{\alpha}$ from equation (i) is not, $\underline{\alpha}$ is a better measure of the actual coefficient of adjustment that is the β_2 derived by solving back from the values derived in estimating equation (7). This simple two-stage procedure also avoids the multicollinearity problem which would be inherent by merely including time as a variable in equation (7), since _ex hypothesi_ there exists a strong trend in the output (or acreage) variable.