Reprinted from THE SOUTHERN ECONOMIC JOURNAL
Vol. XXXVII, No. 3, January, 1971
Printed in U.S.A.

SALES EXPECTATIONS AND SHORT-RUN PRODUCTION DECISIONS*

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I. INTRODUCTION

Because firms are likely to try to smooth production relative to sales, current production decisions should depend in part upon expected future sales. Unfortunately, the one extensive empirical study of this question, that of Belsley [1], has failed to uncover any evidence of such dependence. The data that Belsley uses are of questionable reliability, however, and his negative results may be due to the use of these data. For four industries—Cigarettes, Cigars, Tires, and Cement—rather good monthly data are available on production and sales or inventories, and the purpose of this study is to see whether these data are capable of picking up any effect of expectations of future sales on current production decisions.

The data are used to estimate three different production models: the Belsley model, the Holt *et al.* model, and a lagged adjustment model. In Section II the Holt *et al.* and Belsley models are briefly described and the lagged adjustment model is developed. Section III describes the expectational hypotheses that have been used, and Section IV discusses the data. The results of estimating the three models for the four industries are presented and evaluated in Section V.

II. THE THREE PRODUCTION MODELS

The Holt et al. Model

Let Y_t denote the amount of output produced during period t, S_t the amount sold during period t, V_t the stock of inventories on hand at the end of period t, M_{t-1} the number of workers on hand at the end of period $t-1$, Y_t^p the amount planned (at the beginning of period t) to be produced during period t, and S_{t+i}^e the amount expected (at the beginning of period t) to be sold during period $t+i$.[1] Holt *et al.* [3] postulate various quadratic cost functions for the firm, and on the assumption that firms seek to minimize the sum of expected future costs they arrive at the following equation:[2]

$$Y_t^p = \alpha_0 + \alpha_1 M_{t-1} + \alpha_2 V_{t-1} + \sum_{i=0}^{n} \delta_i S_{t+i}^e . \qquad (1)$$

M_{t-1} in equation (1) reflects the short-run costs of changing the size of the work force, and V_{t-1} reflects inventory holding costs. n in (1) is the length of the decision horizon.

The Belsley Model[3]

Belsley's model is similar to the Holt *et al.* model. Belsley also postulates various quadratic cost functions for the firm and assumes that firms seek to minimize the sum of expected future costs. His equation is similar to (1), with lagged output, Y_{t-1},

* I wish to thank David Belsley for helpful comments on an earlier draft of this paper. I would also like to thank a referee for helpful comments.

[1] In this section it will be assumed that each period consists of the same number of working days and that the daily rate of production and the daily rate of sales are constant within each period. In the following sections this assumption will have to be relaxed, but for now it avoids having to distinguish between *rates* of production or sales during the period and *levels* of production or sales during the period.

[2] The Holt *et al.* cost minimization procedure also yields an equation determining the level of the work force, but this is not of direct concern here.

[3] Belsley actually has two models, one concerned with production-to-stock decisions and one concerned with production-to-order decisions. Since none of the four industries examined in this study produce to order, only Belsley's production-to-stock model is considered here.

replacing lagged employment in the equation:

$$Y_t^p = \alpha_0' + \alpha_1' Y_{t-1} + \alpha_2' V_{t-1} + \sum_{i=0}^{n} \delta_i' S_{t+i}^e . \tag{2}$$

Y_{t-1} in equation (2) reflects the short-run costs of changing the rate of production, and again V_{t-1} reflects inventory holding costs.

The Lagged Adjustment Model

The approach taken here in developing a lagged adjustment model of short-run production decisions is similar to the approach taken in Fair [2] in developing a model of short-run employment decisions. The approach is to be distinguished from the quadratic cost minimizing approach of Holt *et al.* and Belsley. The lagged adjustment model is developed as follows. The firm is assumed to decide at the beginning of period t how much to change the current rate of production. The variables that the firm has knowledge of at this time are the current amount produced, Y_{t-1}, and the stock of inventories on hand, V_{t-1}. The firm is also assumed to have formulated future sales expectations, $S_{t+i}^e (i = 0, 1, 2, \cdots, n)$. Ignoring Y_{t-1} for the moment, let V_t^d denote the short-run desired stock of inventories for the end of period t (desired as of the beginning of period t). Since V_{t-1} and S_t^e are given, once the value for V_t^d is set, the value for the desired amount produced is also set:

$$Y_t^d = S_t^e + V_t^d - V_{t-1} . \tag{3}$$

Y_t^d is the desired amount produced during period t ignoring Y_{t-1}. Equation (3) can be considered to be the ex ante equivalent to the ex post identity, $Y_t \equiv S_t + V_t - V_{t-1}$.

Since inventories can be used to meet part of any expected increase in sales, firms can by the accumulation and decumulation of inventories smooth out fluctuations in production relative to fluctuations in sales. If sales were expected to be constant through time, inventories would really not be needed at all except for such things as insurance against an unexpected increase in sales or breakdown in production, and the desired stock of inventories could be taken to be constant through time. $\bar{V}$ will be used to denote this "long-run" or "average" desired stock of inventories.[4]

Since expected sales do fluctuate in the short run, the short-run desired stock of inventories is likely to fluctuate also. If sales are expected to increase over the next few periods, the short-run desired stock of inventories is likely to be larger than $\bar{V}$ so that part of the increase in sales can come from drawing down inventories rather than by increasing production to the full extent of the increase in sales; and if sales are expected to decrease over the next few periods, the short-run desired stock of inventories is likely to be smaller than $\bar{V}$ so that part of the decrease in sales can come from building up inventories rather than by decreasing production to the full extent of the decrease in sales. The difference between the short-run and long-run desired stock of inventories is thus assumed to be a function of expected future changes in sales:[5]

$$V_t^d - \bar{V} = \sum_{i=1}^{n} \gamma_i (S_{t+i}^e - S_{t+i-1}^e). \tag{4}$$

Equation (4) can be solved for V_t^d and substituted into (3) to eliminate V_t^d from (3). Y_t^d can then be seen to be a function

[4] $\bar{V}$ is likely to be related to some average expected level of sales of the firm, and in the empirical work below it is assumed to be a function of a twenty-four month moving average of past sales. $\bar{V}$, in other words, is considered to be a function of the average level of sales of the past two years, but not of particular short-run monthly or quarterly fluctuations.

[5] Equation (4) is similar to equation (6.9) in [2]. The discussion here of the determinants of the desired stock of inventories closely parallels the discussion in [2, 117–118]. The basic difference between the work in [2] and the work here is that in [2] $\bar{V}$ was assumed to be approximated by a constant and a time trend, whereas here $\bar{V}$ is assumed to be aproximated by a twenty-four month moving average of past sales.

of the expected future changes in sales. Remember that Y_t^d is the desired amount produced ignoring Y_{t-1}. Since there are likely to be short-run adjustment costs in changing the rate of production, only part of any desired change in the rate of production may be planned to be made during any one period. A simple lagged adjustment process for planned production is thus postulated:

$$Y_t^p - Y_{t-1} = \lambda(Y_t^d - Y_{t-1}). \quad (5)$$

Y_t^p denotes the amount planned to be produced for period t, the plans being made at the beginning of period t. Equations (3), (4), and (5) then imply that

$$Y_t^p - Y_{t-1} = \lambda\bar{V} + \lambda S_t^e - \lambda Y_{t-1} - \lambda V_{t-1} + \sum_{i=1}^{n} \lambda\gamma_i(S_{t+i}^e - S_{t+i-1}^e), \quad (6)$$

or

$$Y_t^p - Y_{t-1} = \lambda\bar{V} + (\lambda - \lambda\gamma_1)S_t^e - \lambda Y_{t-1} - \lambda V_{t-1} + \sum_{i=1}^{n-1} \lambda(\gamma_i - \gamma_{i+1})S_{t+i}^e + \lambda\gamma_n S_{t+n}^e. \quad (7)$$

Equations (6) and (7) differ only in that (6) is written in terms of expected sales *changes* and (7) in terms of expected sales *levels*.

It should be noted that equation (7) differs from Belsley's equation (2) in only two basic respects. First, equation (7) includes the long-run desired stock of inventory term, $\lambda\bar{V}$, which equation (2) does not. Secondly, equation (7) includes restrictions on the coefficient of S_t^e, which equation (2) does not. The coefficient of S_t^e, after it is added to $\lambda\gamma_1$ (which can be identified from the last n terms in (7)), should be equal in absolute value to the coefficient of Y_{t-1}.[6] The restriction can be easily tested by estimating the equation

$$Y_t^p - Y_{t-1} = \lambda\bar{V} + \lambda(S_t^e - Y_{t-1}) + \lambda_0 S_t^e + \lambda_1 V_{t-1} + \sum_{i=1}^{n} \lambda\gamma_i(S_{t+i}^e - S_{t+i-1}^e) \quad (8)$$

and noting whether the estimate of λ_0 is significantly different from zero. If the estimate is not significantly different from zero, the restriction is confirmed; otherwise the evidence indicates that the lagged adjustment model is too restrictive.

Note also from equations (6) and (7) that expected future sales appear to enter the equation of the lagged adjustment model naturally as changes instead of levels. The fact that S_t^e also enters separately in the equation, however, implies that (aside from the restriction between the coefficients of S_t^e and Y_{t-1} discussed above) it makes no difference whether the equation is estimated using the levels or changes of expected sales: the estimated coefficients of one equation can always be unscrambled (or scrambled) to get the coefficients of the other. This does not mean, however, that equation (4) for desired inventories can be expressed in terms of the levels of expected sales without restrictions being placed on the level coefficients. In other words, it is not an arbitrary decision whether equation (4) for desired inventories is expressed in terms of expected sales levels or changes. Given that the long-run desired level of inventories, $\bar{V}$, is a function of some average level of sales, it does appear that the difference between the short-run and long-run desired stock of inventories in (4) should be a function of expected *increases* or *decreases* in sales and not merely of expected levels. If, for example, sales were expected to remain constant, the difference between the short-run and long-run desired stock of

[6] Equation (7) also includes the restriction that the coefficient of Y_{t-1} is the same as the coefficient of V_{t-1}. Belsley [1] has pointed out, however, that since V_{t-1} is a stock and Y_{t-1} is a flow, the coefficient estimate of V_{t-1} is sensitive to the time period imposed on the model by the data. Unless the relevant decision period corresponds to the period imposed by the data, the coefficient estimate of V_{t-1} need not correspond to any a priori restriction. Because of this, no possible restriction on the coefficient of V_{t-1} was considered in the work below.

inventories should be zero, as is implied by (4).

It should finally be observed how the lagged adjustment model here compares with the stock adjustment inventory model that is common to most macro-economic studies of inventory investment. From an equation like (3), the planned stock of inventories for the end of period t (denoted as V_t^p) is equal to $Y_t^p - S_t^e + V_{t-1}$. Combining this equation with equations (3) and (5) yields the following equation for planned inventory investment:

$$V_t^p - V_{t-1} + \lambda(V_t^d - V_{t-1}) + (1 - \lambda)(Y_{t-1} - S_t^e). \tag{9}$$

Aside from the $Y_{t-1} - S_t^e$ term (which, of course, should not be ignored), equation (9) is the same as the standard stock adjustment inventory model. In most models, V_t^d is assumed to be a function of only the current level of sales, and what equation (4) and the above discussion suggest is that this specification is likely to be too simple in a study of short-run inventory investment.

III. THE EXPECTATIONAL HYPOTHESES

The variables Y_t^p and S_{t+i}^e ($i = 0, 1, 2, \cdots, n$) in the equations above are not directly observed, and in order to estimate the equations some assumption has to be made about how expectations are formed. It is first assumed that:

$$Y_t^p = Y_t, \tag{10a}$$

$$S_t^e = S_t. \tag{10b}$$

It is assumed, in other words, that expectations for one month ahead are perfect. For the work in [2] on employment decisions, this assumption appeared to be quite realistic.

With respect to the $S_{t+i}^e (i = 1, 2, \cdots, n)$, as in [3], two basic expectational hypotheses are proposed. The first hypothesis is that expectations are perfect:

$$S_{t+i}^e = S_{t+i}, \quad i = 1, 2, \cdots, n. \tag{11}$$

The second (non-perfect) expectational hypothesis is that

$$S_{t+i}^e = S_{t+i-12} + \psi_i(S_{t-1} - S_{t-13}), \quad i = 1, 2, \cdots, n. \tag{12}$$

What (12) says is that sales in month $t + i$ are expected to be what they were in the same month of the preceding year plus a factor (measured as $S_{t-1} - S_{t-13}$) to take into account whether sales have been rising or falling in the current year relative to the preceding year. The ψ_i coefficients may conceivably be different for different i, since as the sales to be predicted move into the future, the firm may put less reliance on immediate past behavior.

Given data on Y_t, S_t, and V_t, an equation like (8) can be estimated under each of the two expectational hypotheses. Under the perfect expectational hypothesis the actual values of the S_{t+i} are used in (8), and under the non-perfect expectational hypothesis the expectational part of (8) becomes (for $n = 3$):

$$\begin{aligned}\sum_{i=1}^{3} \lambda\gamma_i(S_{t+i}^e - S_{t+i-1}^e) &= \lambda\gamma_1(S_{t-11} - S_t) \\ &+ \lambda\gamma_2(S_{t-10} - S_{t-11}) \\ &+ \lambda\gamma_3(S_{t-9} - S_{t-10}) \\ &+ \lambda(\gamma_1\psi_1 + \gamma_2\psi_2 - \gamma_2\psi_1 + \gamma_3\psi_3 \\ &\quad - \gamma_3\psi_2)(S_{t-1} - S_{t-13}).\end{aligned} \tag{13}$$

For the non-perfect expectational hypothesis, if all of the ψ_i coefficients are equal (to, say ψ), then the coefficient of $S_{t-1} - S_{t-13}$ becomes $\lambda\gamma_1\psi$, and ψ can be identified; otherwise the ψ_i coefficients cannot be identified.

IV. DATA CONSIDERATIONS

Belsley used Bureau of Census monthly data on shipments and inventories at the two-digit industry level to estimate his equations. The basic disadvantage of the Census data is that they are based on dollar values rather than physical magnitudes. In addition, the data are based on sample surveys, and for some of the industries the coverage is fairly light. In the study of employment decisions in [2], the Census data were compared with the data that are available from other sources, and the results in general cast doubt on the reliability of the Census data.

There are four three-digit industries for which fairly good data are available on a monthly basis: the Cigarette industry, 211, the Cigar industry, 212, the Tire industry, 301, and the Cement industry, 324. From the Internal Revenue Service, data on Y_t and S_t are available for the Cigarette and Cigar industries; from the Rubber Manufacturers Association, data on Y_t and V_t are available for the Tire industry; and from the Bureau of Mines, data on Y_t and V_t are available for the Cement industry. These data are presented in [2], Tables A-2 through A-5. From the definition, $Y_t \equiv S_t + V_t - V_{t-1}$, given data on Y_t and V_t, data on S_t can be constructed; and given data on Y_t and S_t, data on V_t can be constructed except for an arbitrary base period value.

In the previous sections it has been assumed that each period consists of the same number of working days and that the daily rates of production and sales are constant within each period. This is, of course, not true for the monthly data here, since not all months have the same number of working days and since there is no guarantee that the daily rates of production and sales are constant throughout the month. The best that can be done is to convert Y_t and S_t (which are in units per month) to average daily rates for the month by dividing them by the number of working days in the month. Values for the number of working days in the month were constructed from the FRB assumptions of the number of working days in the week for each industry. The procedure by which this was done is discussed in the data appendix in [2]. All of the flow variables here were thus divided by the constructed number of working days in the month. From now on, then, Y_t, S_t, S_{t+i}, etc. will denote the average daily rates for the respective months.

The data used here are seasonally unadjusted. Belsley presents results using both seasonally adjusted and seasonally unadjusted data, but he prefers the seasonally adjusted data, arguing that "the theory . . . from which the production models are derived does not attempt to account for seasonal effects."[7] As mentioned above, Belsley's model is based on the minimization of the sum of expected future costs, and contrary to what he states, there appears to be no reason why these should be seasonally adjusted costs as opposed to actual costs. The costs of holding, say, a large stock of inventories are real whether or not the large stock is due to seasonal or cyclical factors, and likewise the cost of changing the rate of production is real whether or not the need to change is due to seasonal or cyclical changes in sales.[8] In short, it is real costs that are at issue and not in some sense seasonally adjusted costs. Belsley's concentration on the results achieved using seasonally adjusted data thus seems unwarranted.

The basic period of estimation was taken to be 1952–1965 for the Cigarette and Cigar industries, 1947–1965 for the Tire industry, and 1947–1964 for the Cement industry. There were, however, a number of adjustments made in these basic periods. The adjustments are described in detail in [2], Chapter 4.[9] The actual periods of estimation used here are presented in the data appendix in [2]. Because of the twenty-four month moving average sales variable, the shorter periods of estimation presented in [2] for the

[7] Belsley [1, Section 5.1.3].

[8] Imagine a manager attempting to explain to the stockholders that the company's loss for the year was not serious since it was due only to (recurring) seasonal factors.

[9] For example, a number of observations for the Cigarette, Cigar, and Tire industries were omitted from the periods of estimation because of vacation shut downs that occurred. Also, for the Tire and Cement industries, observations were omitted because of strikes.

Cigar and Tire industries were used here. Also, the same (shorter) period of estimation was used for both the Cigarette and Cigar industries.

V. THE RESULTS

There are two sets of comparisons that need to be made here: comparisons among the Holt *et al.* equation, Belsley's equation, and the equation of the lagged adjustment model, and comparisons between the two expectational hypotheses. Of major concern, of course, is whether for any equation future sales expectations are significant in the determination of the current change in production. The results will be presented as follows. First, estimates of the equation of the lagged adjustment model will be presented under the two expectational hypotheses. Then, using the better expectational hypothesis for each industry, estimates of Belsley's equation and of the Holt *et al.* equation will be presented.

The results of estimating equation (8) of the lagged adjustment model for each of the four industries under both expectational hypotheses are presented in Table I. For each industry the expectational hypothesis that gave the better results has been presented first. (For the non-perfect expectational hypothesis, the coefficient of $S_{t-1} - S_{t-13}$ is denoted as δ.) In estimating equation (8) under the better expectational hypothesis for each industry, the expected future change-in-sales variables were carried forward until they lost their significance.[10] Also, as mentioned above, the long-run desired stock of inventories, $\bar{V}$, has been assumed to be a function of a twenty-four month moving average of past sales:[11] $\beta_1 \sum_{i=1}^{24} S_{t-i}/24$. For the Cigarette and Cigar industries a constant must be included in the equation because the constructed series on the stock of inventories is approximated only up to a constant amount. (See the discussion at the beginning of Section IV.) For the Tire and Cement industries there is no compelling theoretical reason why a constant should be included in the equation, but the estimates of the constant terms in both equations did prove to be marginally significant and the constant was included in the final equations estimated. The results were only slightly different when the constant was suppressed.

Turning first to the expected future sales variables (under the expectational hypothesis that gave the better results for each industry) in Table I, none of them were significant for Cigarettes, three were significant for Cigars, four were significant for Tires, and five were significant for Cement. The $\lambda\gamma_i$ estimates are in general highly significant in Table I, and the overall results strongly indicate that future sales expectations do have a significant effect on current production decisions.

Comparing the two expectational hypotheses in Table I, for the Cement industry both expectational hypotheses work almost as well.[12] There is little to choose between the two hypotheses, although the fit under the non-perfect expectational hypothesis is slightly better. For the Cigar industry the results under the perfect expectational hypothesis are somewhat better: the fit is better and the $\lambda\gamma_i$ coefficient estimates are more significant. For the Tire industry the perfect expectational hypothesis is clearly better. None of the $\lambda\gamma_i$ estimates are significant under the non-perfect expectational hypothesis, and the fit is much worse. The perfect expectational hypothesis, in other

[10] "Significance" here is interpreted rather loosely to mean a t-statistic of the coefficient estimate greater than two in absolute value. A variable is said to be "significant" if its coefficient estimate is significant.

[11] In order to avoid the loss of too many observations, the first twelve observations for $\bar{V}$ were assumed to be a function of a twelve-month moving average of past sales.

[12] Notice that the estimate of the coefficient δ of $S_{t-1} - S_{t-13}$ is not significant, which, under the assumption that all of the ψ_i in equation (12) are equal, implies that the rate of sales in a specific future month is expected to be equal to the rate of sales that prevailed during the same month of the preceding year. Expectations in this case are static.

TABLE I

Parameter estimates for equation (8) of the lagged adjustment model under a) the expectational hypothesis that gave the better results for each industry b) the alternative (and inferior) expectational hypothesis.

$$Y_t^p - Y_{t-1} = \beta_0 + \lambda\beta_1 \sum_{i=1}^{24} S_{t-i}/24 + \lambda(S_t^e - Y_{t-1}) + \lambda_0 S_t^e \lambda_1 V_{t-1} + \sum_{i=1}^{n} \lambda\gamma_i(S_{t+i}^e - S_{t+i-1}^e)$$

Industry	No. of obs.	$\hat{\beta}_0$	$\lambda\hat{\beta}_1$	$\hat{\lambda}$	$\hat{\lambda}_0$	$\hat{\lambda}_1$	$\lambda\hat{\gamma}$	$\lambda\hat{\gamma}$	$\lambda\hat{\gamma}_3$	$\lambda\hat{\gamma}_4$	$\lambda\hat{\gamma}_5$	$\hat{\delta}$	R^2	SE	DW
Cigarettes	96	−99.63	.0019	1.009	.017	−.0101							.990	11.79	2.19
		(3.85)	(2.07)	(80.28)	(1.37)	(3.43)									
a) Cigars	96	−166.74	.0327	.871	.012	−.0056	.451	.226	.165				.622	21.79	2.02
		(4.11)	(3.31)	(10.30)	(0.14)	(3.27)	(5.32)	(3.14)	(2.83)						
b) Cigars	96	−145.12	.0165	.875	.269	−.0058	.497	.276	.129			.113	.560	23.64	2.26
		(3.26)	(1.11)	(8.45)	(1.21)	(2.92)	(3.37)	(2.49)	(1.60)			(1.18)			
a) Tires	99	−34.66	.0044	.490	.074	−.0013	.282	.291	.264	.106			.549	19.20	1.76
		(2.08)	(1.15)	(8.07)	(1.00)	(2.13)	(4.26)	(4,87)	(4.81)	(2.35)					
b) Tires	99	−22.19	.0090	.396	−.122	−.0001	.002	.036	.083	.033		.012	.426	21.78	1.56
		(1.19)	(1.73)	(5.79)	(1.20)	(0.18)	(0.03)	(0.61)	(1.46)	(0.68)		(0.26)			
a) Cement	187	−49.96	−.0024	.486	.218	−.0022	.291	.241	.109	.184	.158	−.031	.872	33.21	1.34
		(2.51)	(1.26)	(14.28)	(4.51)	(3.76)	(8.14)	(7.31)	(4.30)	(7.16)	(5.76)	(0.81)			
b) Cement	187	−65.75	.0014	.529	.121	−.0024	.255	.161	.112	.159	.095		.864	34.11	1.27
		(3.12)	(0.78)	(16.26)	(2.93)	(4.00)	(7.83)	(5.48)	(4.24)	(6.18)	(4.13)				
a) Cement	185	−205.99	.0133	.664	.176	−.0090	.383	.289	.159	.185	.106	−.016	.892	30.47	1.94
		(3.48)	(3.93)	(18.18)	(2.93)	(7.41)	(8.14)	(7.36)	(5.25)	(7.10)	(4.97)	(0.51)			

Notes: t-statistics are in parentheses.

$\hat{\delta}$ is the coefficient estimate of $S_{t-1} - S_{t-13}$ under the non-perfect expectational hypothesis.

None of the expectational variables was significant under either hypothesis for the Cigarette industry. The third equation for the Cement industry was estimated under the assumption of first order serial correlation of the error terms. The estimate of the serial correlation coefficient was .740.

words, gives good results for all three industries, whereas the non-perfect expectational hypothesis gives good results only for Cement, with somewhat poorer results for Cigars and considerably poorer results for Tires. If one thus had to choose between the two hypotheses, he would certainly pick the perfect expectational hypothesis as giving the better results.[13]

The coefficient λ_0 of S_t^e in Table I is expected to be zero under the lagged adjustment model. The estimate of λ_0 is not significantly different from zero for the Cigarette, Cigar, and Tire industries, but it is significantly positive for the Cement industry. The estimate of the coefficient of the twenty-four month moving average sales variable is positive, as expected, for the Cigarette and Cigar industries, but it is not significant for the Tire and Cement industries. The estimate of the coefficient of V_{t-1} is significantly negative, as expected, for all four industries. The speed of adjustment coefficient λ varies from 1.009 for the Cigarette industry to .486 for the Cement industry. The results of estimating the lagged adjustment model are thus reasonably good. Only for the Cement industry is the estimate of λ_0 significantly different from zero, and the inventory variable is significant for all four industries.

One final note on the results in Table I. The Durbin-Watson statistics presented in the table are biased toward two because of the existence of the lagged dependent variable among the explanatory variables. The difficulty with trying to estimate the first order serial correlation coefficient for the Cigarette, Cigar, and Tire industries is the large number of gaps in the sample periods. Either a significant percentage of the observations has to be omitted or the sample has to be pieced together in the

[13] Similar to the work on employment decisions in [2, 81–84], a "weighted average" of the two expectational hypotheses was also tried in the estimation of the equations, but the results were dominated by the perfect expectational hypothesis for the Cigar and Tire industries and by the nonperfect expectational hypothesis for the Cement industry.

TABLE II

Parameter estimates for equation (2) of Belsley's model under the expectational hypothesis which gave the better results for each industry.

$$Y_t^p - Y_{t-1} = \alpha_0' + (\alpha_1' - 1)Y_{t-1} + \alpha_2' V_{t-1} + \psi_0' S_t^e + \sum_{i=1}^{n} \psi_i'(S_{t+i}^e - S_{t+i-1}^e)$$

Industry	No. of obs.	$\hat{\alpha}_0'$	$\hat{\alpha}_1' - 1$	$\hat{\alpha}_2'$	$\hat{\psi}_0'$	$\hat{\psi}_1'$	$\hat{\psi}_2'$	$\hat{\psi}_3'$	$\hat{\psi}_4'$	$\hat{\psi}_5'$	$\hat{\delta}$	R^2	SE	DW
Cigarettes	96	−60.58	−1.000	−.0061	1.035							.989	12.00	2.35
		(3.36)	(83.36)	(2.69)	(83.64)									
Cigars	96	−45.15	−.789	−.0015	.999	.520	.270	.186				.575	22.97	2.15
		(2.49)	(9.26)	(1.20)	(9.26)	(6.00)	(3.62)	(3.03)						
Tires	99	−21.22	−.465	−.0011	.593	.297	.306	.284	.124			.542	19.23	1.84
		(1.78)	(8.20)	(1.87)	(8.09)	(4.56)	(5.22)	(5.43)	(2.89)					
Cement	187	−63.45	−.518	−.0025	.693	.274	.225	.102	.172	.140	−.022	.871	33.26	1.26
		(3.78)	(22.89)	(4.93)	(22.02)	(8.27)	(7.38)	(4.11)	(7.19)	(6.01)	(0.60)			
Cement	185	−59.91	−.531	−.0033	.725	.301	.235	.117	.183	.131	−.012	.889	30.82	1.91
		(2.61)	(20.75)	(4.66)	(17.92)	(7.81)	(7.15)	(4.49)	(7.59)	(6.08)	(0.34)			

Notes: t-statistics are in parentheses.
$\hat{\delta}$ is the coefficient estimate of $S_{t-1} - S_{t-13}$ under the non-perfect expectational hypothesis.
The second equation for the Cement industry was estimated under the assumption of first order serial correlation of the error terms. The estimate of the serial correlation coefficient was .412.

TABLE III

Parameter estimates for equation (1) of the Holt *et al.* model under the expectational hypothesis that gave the better results for each industry.

$$Y_t^p = \alpha_0 + \alpha_1 M_{t-1} + \alpha_2 V_{t-1} + \psi_0 S_t^e + \sum_{i=1}^{n} \psi_i (S_{t+i}^e - S_{t+i-1}^e)$$

Industry	No. of obs.	$\hat{\alpha}_0$	$\hat{\alpha}_1$	$\hat{\alpha}_2$	$\hat{\psi}_0$	$\hat{\psi}_1$	$\hat{\psi}_2$	$\hat{\psi}_3$	$\hat{\psi}_4$	$\hat{\psi}_5$	$\hat{\delta}$	SE	DW
Cigarettes	96	−39.76	−.092	−.0064	1.039							11.97	2.36
		(1.14)	(0.68)	(2.87)	(95.07)								
Cigars	96	−49.13	.013	−.0001	1.212	.595	.316	.175				23.74	1.78
		(1.44)	(0.23)	(0.44)	(13.86)	(6.40)	(3.96)	(2.70)					
Tires	99	−66.07	.062	−.0002	1.074	.633	.562	.432	.227			26.83	1.11
		(1.20)	(1.30)	(0.26)	(13.36)	(8.08)	(7.61)	(6.08)	(3.78)				
Cement	187	−210.17	.892	.0017	.824	.019	.132	.116	.187	.148	.071	60.32	1.10
		(2.39)	(3.85)	(1.79)	(14.76)	(0.34)	(2.41)	(2.60)	(4.31)	(3.50)	(1.05)		
Cement	185	−4.87	1.587	−.0173	1.074	.540	.411	.259	.238	.110	.008	33.97	1.62
		(0.02)	(5.22)	(12.94)	(17.91)	(9.91)	(9.03)	(7.57)	(8.32)	(5.03)	(0.26)		

Notes: t-statistics are in parentheses.
$\hat{\delta}$ is the coefficient estimate of $S_{t-1} - S_{t-13}$ under the non-perfect expectational hypothesis.
The second equation for the Cement industry was estimated under the assumption of first order serial correlation of the error terms. The estimate of the serial correlation coefficient was .986.

manner done for the employment and hours equations in [2, 174–175]. The Cement industry appears to show the most serial correlation in Table I, however, and since there is only one gap in the period of estimation for this industry, the equation can be re-estimated under the hypothesis that the residuals are first order serially correlated, with the loss of only two observations. The results of estimating this equation under the assumption of first order serial correlation are presented in the last row of Table I.[14] The estimate of the first order serial correlation coefficient is fairly large at .740, and some of the coefficient estimates have been substantially changed. The coefficient esti-

[14] The equation was estimated by the Cochrane-Orcutt iterative technique. Under the assumption of first order serially correlated errors, the estimates are consistent, even though there is a lagged dependent variable among the regressors. See Malinvaud [4, 469fn.] for an outline of a proof of this.

mate of V_{t-1} has changed from $-.0022$ to $-.0090$, the coefficient estimate of $S_t^e - Y_{t-1}$ from .486 to .664, and the coefficient estimate of the moving average sales variable from $-.0024$ to .0133. The coefficient estimate of the moving average sales variable is now significant in the equation and the coefficient estimate of S_t^e has lost some of its significance, both results being favorable for the lagged adjustment model.

The results of estimating equation (2) of Belsley's model are presented in Table II. As was the case for the lagged adjustment equation, in estimating Belsley's equation the perfect expectational hypothesis gave better results for the Cigar and Tire industries and the non-perfect expectational hypothesis gave slightly better results for the Cement industry. Only the better results are presented in Table II. Equation (2) was estimated in the form presented at the top of Table II to make the results more readily comparable with the results in Table I.

The results in Table II again indicate that, except for the Cigarette industry, future sale expectations are highly significant in the determination of current production changes. Comparing the other coefficient estimates, the estimate of α_1' for the Cigarette industry is clearly not significantly different from zero, and the estimate of the coefficient α_2' of V_{t-1} is not significant for the Cigar and Tire industries. In the last row of Table II the results of estimating the equation for the Cement industry under the assumption of first order serial correlation of the error terms are presented. The estimate of the serial correlation coefficient is of moderate size (.412), but the other coefficient estimates have not been substantially changed.

Comparing the results of Belsley's model in Table II with the results of the lagged adjustment model in Table I, the lagged adjustment model appears to be an improvement over Belsley's model since the inventory variable, V_{t-1}, comes in more significant in Table I than in Table II. Otherwise, there is little to choose between the results for the two models. The results do, of course, strongly indicate under either model that future sales expectations are significant in determining current production decisions. Belsley's negative results in this regard may thus be due to the use of questionable data.

Turning finally to the Holt *et al.* model, the results of estimating equation (1) are presented in Table III. Only the results of the better expectational hypothesis for each industry are presented in Table III. The data on M_{t-1} used in estimating the equations are Bureau of Labor Statistics data on the number of production workers employed for each industry. The results in Table III are clearly not very good. The sales expectations variables are still quite significant, but M_{t-1} is significant only for the Cement industry and V_{t-1} is significant only for the Cigarette industry and for one of the two estimates for the Cement industry. Also, even for the Cement industry, where M_{t-1} is significant in Table III, M_{t-1} lost its significance when Y_{t-1} was added to the equation. There is thus little evidence from these results that the current number of workers on hand is a significant factor in determining production for the forthcoming period, and the overall evidence indicates that the Holt *et al.* model is not realistic. A similar conclusion was reached in [2] with respect to the Holt *et al.* employment model.

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