SALES EXPECTATIONS AND SHORT-RUN PRODUCTION DECISIONS

Ray C. Fair

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Princeton University
Econometric Research Program
207 Dickinson Hall
Princeton, New Jersey

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I. INTRODUCTION

There are two basic approaches which have been followed in the study of short-run production decisions. Generally, macroeconomic studies, such as those of Darling and Lovell [2], have concentrated on the inventory investment decision, while the more disaggregate studies, such as those of Holt et al. [4] and Belsley [1], have concentrated directly on the production decision. If sales are assumed to be exogenous, then decisions on production and decisions on inventory investment are of course not independent. Because of the definition that production equals sales plus the change in the stock of inventories, the decision on how much to produce for a certain period automatically implies the decision on inventory investment for the period, or vice versa.

In both the models of Holt et al. and Belsley, future sales expectations are assumed to be important determinants of current production decisions. Because of short-run adjustment costs, firms are likely to try to smooth fluctuations in production relative to fluctuations in sales in the short run, and thus current production

*I wish to thank David Belsley for making a copy of the manuscript of his forthcoming book [1] available to me and for helpful comments on an earlier draft of this paper.

decisions should be determined at least in part by expected future sales. Unfortunately, the one extensive empirical study in the field -- that of Belsley at the two-digit industry level -- has failed to uncover any evidence that expected future sales are significant in the determination of current production decisions.

It is the contention of this paper that Belsley's negative results are not indicative of the real world situation, but are due to the use of questionable data. Fortunately, for four three-digit U.S. manufacturing industries there are rather good data available, and it is the main purpose of this study to see whether these data are capable of picking up any effect of future sales expectations on current production decisions. Using these data, three different production models will be estimated below -- the Holt et al. model, the Belsley model, and a lagged adjustment model. In Section II the Holt et al. and Belsley models will be briefly described and the lagged adjustment model will be developed. The lagged adjustment model yields an estimating equation which is similar to Belsley's, and the model can to some extent be looked upon as a simplified, lagged adjustment alternative to Belsley's cost minimization model. In Section III the expectational hypotheses which have been used in the estimation of the equations are described, and in Section IV the data are described and the various data problems discussed. Finally, in Section V the results of estimating the three models for the four industries are presented and evaluated.

II. THE THREE PRODUCTION MODELS

Belsley has argued rather extensively that production to stock decisions should be distinguished from production to order decisions, that the determinants of each are likely to be different. Empirically it is very difficult to distinguish between the two kinds of production (there are industries which produce solely to stock but none which produce solely to order), but Belsley's results, even though they are based on some very restrictive assumptions, do seem to indicate that the determinants of the two kinds of production are different. Fortunately, none of the industries examined in this study produces to order, and so the difficulty of trying to distinguish between the two kinds of production can be avoided. It should be kept in mind, however, that the conclusions reached below are strictly relevant only for production to stock decisions.

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. postulate various quadratic cost functions for the firm and on the assumption that firms seek to minimize the sum of expected future costs arrive at the following equation:[2]

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

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.

<u>The Belsley Model</u>

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} replacing lagged employment in the equation:

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

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.

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[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 <u>rates</u> of production or sales during the period and <u>levels</u> 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.

A Lagged Adjustment Model

For comparison purposes an alternative model of short-run production decisions will be developed here. The approach taken here is similar to the one used in Fair [3] in developing a model of short-run employment decisions and avoids the quadratic cost minimization approach of Holt et al. and Belsley. In the study of employment decisions in [3] the cost minimization approach of Holt et al. was avoided because some of the Holt et al. quadratic cost approximations appeared to be unrealistic, especially the overtime cost approximation. For the study of production decisions, however, a model such as Belsley's does not appear to rest on any obviously unrealistic cost approximations, and the primary reason for taking a different approach here is the desire to provide a simplier, lagged adjustment alternative to Belsley's model.

The model is developed as follows. At the beginning of period t it is assumed that the firm decides how much to change the current rate of production. The variables which 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, $S^e_{t+i} (i = 0,1,2,\ldots,n)$. Ignoring Y_{t-1} for the moment, let V^d_t 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^e_t are given, once the value for V^d_t is set the value for the desired amount produced is also set:

(3) $$Y^d_t = S^e_t + V^d_t - V_{t-1} .$$

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. $\bar{\bar{V}}$ will be used to denote this "long-run" or "average" desired stock of inventories.[1]

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 $\bar{\bar{V}}$ 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 $\bar{\bar{V}}$ 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

[1] $\bar{\bar{V}}$ 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. $\bar{\bar{V}}$ 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.

function of expected future changes in sales:[1]

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

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

$$(5) \qquad Y_t^p - Y_{t-1} = \lambda(Y_t^d - Y_{t-1}), \qquad 0 \leqq \lambda \leqq 1 .$$

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

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

or

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

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[1] Equation (4) is similar to equation (6.9) in [3]. The discussion here of the determinants of the desired stock of inventories closely parallels the discussion in [3], pp. 117-118. The basic difference between the work in [3] and the work here is that in [3] $\bar{V}$ was assumed to be approximated by a constant and a time trend, whereas here $\bar{V}$ is assumed to be approximated by a twenty-four month moving average of past sales.

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 coefficients of S_t^e, Y_{t-1}, and V_{t-1}, which equation (2) does not. From (7) it can be seen that the lagged adjustment process (4) implies that the coefficient of Y_{t-1} in the equation determining the planned change in production should be equal to the coefficient of V_{t-1} and that 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}.

With respect to the coefficient of V_{t-1} in an equation like (7), Belsley has noted[1] that since V_{t-1} is a stock and S_t^e and Y_{t-1} are flows, 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. Interestingly enough, Belsley's cost minimization model also implies that the coefficients of S_t^e and V_{t-1} should be equal in absolute value, although he presents the above argument plus some others for why this is not likely to be true for his estimates.

[1]Belsley [1], Section 5.2.1.

Ignoring, then, any possible restriction on the coefficient of V_{t-1} in (7), the only restriction is on the coefficient of S_t^e. This restriction can be easily tested by estimating the equation

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

and noting whether the estimate of λ_o 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 on 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 should be zero, as is implied by (4).

It should finally be observed how the lagged adjustment model here compares with the standard stock adjustment inventory model which 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:

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

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.

This concludes the discussion of the three production models. The models will be estimated and compared in Section V, after a discussion of the expectational hypotheses and the data in the next two sections.

III. THE EXPECTATIONAL HYPOTHESES

The variables Y_t^p and S_{t+i}^e $(i=0,1,2,\ldots n)$ 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. The data which are used below are monthly data, and if decisions are actually made on less than a monthly basis and if production is adjusted more often than once a month, it seems likely that the assumption that expectations are perfect for one month ahead will be realistic. This assumption was in fact confirmed from the results of the work in [3] on employment decisions, and it will thus be assumed here that

(10a) $$Y_t^p = Y_t ,$$

(10b) $$S_t^e = S_t .$$

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

(11) $$S_{t+i}^e = S_{t+i}, \qquad i = 1,2,\ldots,n .$$

The second (non-perfect) expectational hypothesis is that

(12) $$S_{t+i}^e = S_{t+i-12} + \Phi_i(S_{t-1} - S_{t-13}), \qquad i=1,2,\ldots,n .$$

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 Φ_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.

As argued in [3], the hypothesis that expectations are perfect for a few months in advance may not be as unreasonable as it sounds. Firms are likely to have more information at their disposal regarding future demand conditions than merely information on past demand conditions. If firms do not use a naive equation like (12) to forecast and if the forecasting technique they do use is fairly accurate, then the perfect expectational hypothesis should be a better approximation of how expectations are formed than various non-perfect expectational hypotheses like the one in (12).

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):

$$(13)\quad \sum_{i=1}^{3} \lambda\gamma_i(S^e_{t+i} - S^e_{t+i-1}) = \lambda\gamma_1(S_{t-11} - S_t) + \lambda\gamma_2(S_{t-10} - S_{t-11}) + \lambda\gamma_3(S_{t-9} - S_{t-10})$$

$$+ \lambda(\gamma_1\Phi_1 + \gamma_2\Phi_2 - \gamma_2\Phi_1 + \gamma_3\Phi_3 - \gamma_3\Phi_2)(S_{t-1} - S_{t-13}).$$

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

IV. DATA CONSIDERATIONS

Belsley uses Bureau of Census monthly data at the two-digit manufacturing 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 disaggregate industries the coverage is such that the data are not too reliable. The Bureau of the Census does not publish much of the two-and three-digit industry data because of the questionable reliability of the estimates, particularly the estimates before 1960. In the study of employment decisions in [3] the Census data were compared with data from the Federal Reserve Board (FRB) for four three-digit manufacturing industries, and as expected, the FRB data gave considerably better results. The results in [3] certainly cast some doubt on the reliability of the Bureau of 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 Tires and Inner Tubes industry, 301, and the Cement industry, 324. From the Internal Revenue Service data on Y_t and S_t are available for 211 and 212; from the Rubber Manufacturers Association data on Y_t and V_t are available for 301; and from the Bureau of Mines data on Y_t and V_t are available for 324. These data are presented in [3], 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 [3]. 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."[1] 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.[2] In short, it is real costs which 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 industries 211 and 212, 1947-1965 for industry 301, and 1947-1964 for industry 324. There were, however, a number of adjustments made in these basic periods. For example, in industries 211, 212, and 301 a significant percentage of firms shut down for vacations in July (usually the first two weeks), and in industries 211 and 212 a significant number of firms also shut down during the Christmas week in December. In July and December many of these firms find

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[1] Belsley [1], Section 5.1.3.

[2] 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.

demand at low levels anyway, and they find it to their advantage to shut the entire plant down for a week or two for vacations, rather than to keep the plant open and spread the vacations over a longer period of time. For these shutdown periods the average daily rate of output for the month is obviously determined by other factors besides those specified in the model above, and it was thus decided to exclude from the periods of estimation the months in which shutdowns occurred. This means for example, that for industries 211 and 212, which shut down in July and December, the values of $Y_t - Y_{t-1}$ for June to July, July to August, November to December, and December to January were excluded. Excluding these observations does not completely solve the shutdown problem, however, since firms are likely to behave somewhat differently, other things being equal, in the months which immediately precede and follow shutdown periods than in other months. It is almost impossible to account for all of these problems because of the asymmetries involved, but the exclusion procedure here should account for many of the difficulties.

In industries 301 and 324 there were significant strikes (involving 10,000 workers or more) during the 1947-1965 period.[1] In the regression for these two industries the strike observations were omitted, as well as the observations for the two or three months before and after the strike.

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[1]The approximate dates of the strikes are presented in [3], Table 4.2. There was one strike in 324 during the period and ten in 301.

The actual periods of estimation used here are presented in the data appendix in [3]. Because of the twenty-four month moving average sales variable, the shorter periods of estimation presented in [3] for industries 212 and 301 were used here. Also, the same (shorter) period of estimation was used for both industries 211 and 212.

V. THE RESULTS

There are two sets of comparisons which need to be made here: comparisons among the Holt et al. equation, Belsley's equation, and the equation developed in this paper, 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 developed in this paper 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 1. For each industry the expectational hypothesis which gave the better results has been presented first -- the perfect expectational hypothesis for industries 212 and 301 and non-perfect expectational hypothesis for industry 324.

TABLE 1

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

$$Y^p_t - Y_{t-1} = \beta_o + \lambda\beta_1 \sum_{i=1}^{24} S_{t-i}/24 + \lambda(S^e_t - Y_{t-1}) + \lambda_o S^e_t - \lambda_1 V_{t-1} + \sum_{i=1}^{n} \lambda\gamma_i (S^e_{t+i} - S^e_{t+i-1})$$

Industry	No. of obs.	$\hat{\beta}_o$	$\hat{\lambda\beta}_1$	$\hat{\lambda}$	$\hat{\lambda}_o$	$\hat{\lambda}_1$	$\hat{\lambda\gamma}_1$	$\hat{\lambda\gamma}_2$	$\hat{\lambda\gamma}_3$	$\hat{\lambda\gamma}_4$	$\hat{\lambda\gamma}_5$	$\hat{a}_\delta$	R^2	SE	DW
211[b]	96	-99.63 (3.85)	.0019 (2.07)	1.009 (80.28)	.017 (1.37)	-.0101 (3.43)							.990	11.79	2.19
a) 212	96	-166.74 (4.11)	.0327 (3.31)	.871 (10.30)	.012 (0.14)	-.0056 (3.27)	.451 (5.32)	.226 (3.14)	.165 (2.83)				.622	21.79	2.02
b) 212	96	-145.12 (3.26)	.0165 (1.11)	.875 (8.45)	.269 (1.21)	-.0058 (2.92)	.497 (3.37)	.276 (2.49)	.129 (1.60)			.113 (1.18)	.560	23.64	2.26
a) 301	99	-34.66 (2.08)	.0044 (1.15)	.490 (8.07)	.074 (1.00)	-.0013 (2.13)	.282 (4.26)	.291 (4.87)	.264 (4.81)	.106 (2.35)			.549	19.20	1.76
b) 301	99	-22.19 (1.19)	.0090 (1.73)	.396 (5.79)	-.122 (1.20)	-.0001 (0.18)	.002 (0.03)	.036 (0.61)	.083 (1.46)	.033 (0.68)		.012 (0.26)	.426	21.78	1.56
a) 324	187	-49.96 (2.51)	-.0024 (1.26)	.486 (14.28)	.218 (4.51)	-.0022 (3.76)	.291 (8.14)	.241 (7.31)	.109 (4.30)	.184 (7.16)	.158 (5.76)	-.031 (0.81)	.872	33.21	1.34
b) 324	187	-65.75 (3.12)	.0014 (0.78)	.529 (16.26)	.121 (2.93)	-.0024 (4.00)	.255 (7.83)	.161 (5.48)	.112 (4.24)	.159 (6.18)	.095 (4.13)		.864	34.11	1.27
a) 324[c]	185	-205.99 (3.48)	.0133 (3.93)	.664 (18.18)	.176 (2.93)	-.0090 (7.41)	.383 (8.14)	.289 (7.36)	.159 (5.25)	.185 (7.10)	.106 (4.97)	-.016 (0.51)		30.47	1.94

(t-statistics are in parentheses)

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

[b] None of the expectational variables was significant under either hypothesis.

[c] Estimated under the assumption of first order serial correlation of the error terms. Estimate of the serial correlation coefficient is .740.

(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.[1] For industry 211 none of the future change in sales variables were significant under either hypothesis. Also, as mentioned above, the long-run desired stock of inventories $\bar{V}$ has been assumed to be a function if a twenty-four month moving average of past sales[2]: $\beta_1 \sum_{i=1}^{24} S_{t-i}/24$. For industries 211 and 212 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 industries 301 and 324 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 surpressed.

Turning first to the expected future sales variables (under the expectational hypothesis which gave the better results for each industry) in Table 1, none of them were significant for 211, three were significant for 212, four were significant for 301, and five

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[1] Because of the inclusion of a lagged dependent among the explanatory variables, "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.

[2] 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.

were significant for 324. For 212 and 301 the perfect expectational hypothesis gave the better results and for 324 the non-perfect expectational hypothesis gave slightly better results. Notice that for 324 the estimate of the coefficient δ of $S_{t-1} - S_{t-13}$ is not significant, which, under the assumption that all of the Φ_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 which prevailed during the same month of the preceding year. Expectations in this case are static. In summary, for industries 212, 301, and 324 the $\lambda\gamma_i$ estimates are quite significant in Table 1, and the overall results rather strongly indicate that future sales expectations do have a significant effect on current production decisions.

Comparing the two expectational hypotheses in Table 1, it is seen that for industry 324 both expectational hypotheses work almost as well. There is little to choose between the two hypotheses, although the fit under the non-perfect expectational hypothesis is slightly better. For industry 212 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 industry 301 the perfect expectational hypothesis is clearly better. None of the $\lambda\gamma_i$ estimates is significant under the non-perfect expectational hypothesis, and the fit is much worse. In summary, then, the perfect expectational hypothesis gave good results for all three industries, whereas the non-perfect expectational hypothesis gave good results only for 324, with somewhat poorer results for 212 and considerably poorer results for 301. If one thus had to choose between the two hypotheses, he would certainly pick the perfect expectational hypothesis as giving the better results.[1]

The coefficient λ_o of S_t^e in Table 1 is expected to be zero under the lagged adjustment model. The estimate of λ_o is not significantly different from zero for industries 211, 212, and 301, but it is significantly positive for industry 324. The estimate of the coefficient of the twenty-four month moving average sales variable is positive, as expected, for industries 211 and 212, but it is not significant for industries 301 and 324. The estimate of the coefficient of V_{t-1} is signficantly negative, as expected, for all four industries. The speed of adjustment coefficient λ varies from 1.009 for industry 211 to .486 for industry 324. Ignoring the expected future sales variables (which will also be seen to be significant under the Belsley and Holt et al. models), the results of estimating the lagged adjustment model are inconclusive. The model performs well for industries 211 and 212, less well for industry 301, and poorly for industry 324. Before passing final judgment on the model, however, the results in Table 1 should be compared with the results of estimating the Belsley and Holt et al. models.

One final note on the results in Table 1. The Durbin-Watson statistics[2] presented in the tables 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

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[1] Similar to the work on employment decisions in [3], pp. 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 industries 212 and 301 and by the non-perfect expectational hypothesis for industry 324.

[2] The DW statistics have been adjusted for the number of gaps in the equations in the manner described in [3], pp. 173-174.

serial correlation coefficient for 211, 212, and 301 is the large number of gaps in the equations. Either a significant percentage of the observations has to be omitted or the sample has to be pieced together in the manner done for the employment and hours equations in [3], pp. 174-175. Industry 324 appears to show the most serial correlation in Table 1, 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 1.[1] 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 estimate 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 2. As was the case for the lagged adjustment equation, in estimating Belsley's equation the perfect expectational

[1]The equation was estimated by the Chochrane-Orcutt iterative technique with a tolerance level between successive estimates of ρ of .005. 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 [5], p. 469, n. ††, for an outline of a proof of this.

TABLE 2

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

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

Industry	No. of obs.	$\hat{\alpha}_o'$	$\hat{\alpha}_1'-1$	$\hat{\alpha}_2'$	$\hat{\psi}_o'$	$\hat{\psi}_1'$	$\hat{\psi}_2'$	$\hat{\psi}_3'$	$\hat{\psi}_4'$	$\hat{\psi}_5'$	$\hat{\delta}$[a]	R^2	SE	DW
211	96	-60.58 (3.36)	-1.000 (83.36)	-.0061 (2.69)	1.035 (83.64)							.989	12.00	2.35
212	96	-45.15 (2.49)	-.789 (9.26)	-.0015 (1.20)	.999 (9.26)	.520 (6.00)	.270 (3.62)	.186 (3.03)				.575	22.97	2.15
301	99	-21.22 (1.78)	-.465 (8.20)	-.0011 (1.87)	.593 (8.09)	.297 (4.56)	.306 (5.22)	.284 (5.43)	.124 (2.89)			.542	19.23	1.84
324	187	-63.45 (3.78)	-.518 (22.89)	-.0025 (4.93)	.693 (22.02)	.274 (8.27)	.225 (7.38)	.102 (4.11)	.172 (7.19)	.140 (6.01)	-.022 (0.60)	.871	33.26	1.26
324[b]	185	-59.91 (2.61)	-.531 (20.75)	-.0033 (4.66)	.725 (17.92)	.301 (7.81)	.235 (7.15)	.117 (4.49)	.183 (7.59)	.131 (6.08)	-.012 (0.34)		30.82	1.91

(t-statistics are in parentheses)

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

[b] Estimated under the assumption of first order serial correlation of the error terms. Estimate of the serial correlation coefficient is .412.

hypothesis gave better results for industries 212 and 301 and the non-perfect expectational hypothesis gave slightly better results for industry 324. Only the better results are presented in Table 2. Equation (2) was estimated in the form presented at the top of Table 2 to make the results more readily comparable with the results in Table 1.

The results in Table 2 again indicate that, except for industry 211, future sales expectations are highly significant in the determination of current production changes. Comparing the other coefficient estimates, the estimate of α_1' for industry 211 is clearly not significantly different from zero and the estimate of the coefficient α_2' of V_{t-1} is not significant for industries 212 and 301. In the last row of Table 2 the results of estimating the equation for 324 under the assumption of first order serial correlation of the error terms are presented. The estimate of the serial correlation coefficient is .412, but the other coefficient estimates have not been substantially changed.

Comparing the results of Belsley's model in Table 2 with the results of the lagged adjustment model in Table 1, it is difficult to make a choice on which are better. The lagged adjustment model appears to be an improvement over Belsley's model in that the inventory variable V_{t-1} comes in more significant in Table 1 than in Table 2, but it is disturbing that for 301 the moving average sales variable is not significant in Table 1 and that for 324 the estimate of λ_o is. The overall evidence may slightly favor the lagged adjustment model, but the evidence is admittedly not very strong. The results do, of course, strongly indicate under either model that future sales expectations are significant in determining current production decisions, that Belsley's negative results are probably 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 3. Only the results of the better expectational hypothesis for each industry are presented in Table 3. 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 3 are clearly not very good. The sales expectations variables are still quite significant, but M_{t-1} is significant only for industry 324 and V_{t-1} is significant only for industry 211 and for one of the two estimates for industry 324. The fits are noticeably worse in Table 3 than in Tables 1 and 2. Also, even for industry 324, 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 [3] with respect to the Holt et al. employment model.

The employment model developed in [3] will not be discussed here, but it should perhaps be pointed out that the lagged adjustment production model developed in this paper and the results achieved here are consistent with the employment model and the results achieved in [3].

TABLE 3

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

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

Industry	No. of obs.	$\hat{\alpha}_o$	$\hat{\alpha}_1$	$\hat{\alpha}_2$	$\hat{\psi}_o$	$\hat{\psi}_1$	$\hat{\psi}_2$	$\hat{\psi}_3$	$\hat{\psi}_4$	$\hat{\psi}_5$	$\hat{\delta}$[a]	SE	DW
211	96	-39.76 (1.14)	-.092 (0.68)	-.0064 (2.87)	1.039 (95.07)							11.97	2.36
212	96	-49.13 (1.44)	.013 (0.23)	-.0001 (0.44)	1.212 (13.86)	.595 (6.40)	.316 (3.96)	.175 (2.70)				23.74	1.78
301	99	-66.07 (1.20)	.062 (1.30)	-.0002 (0.26)	1.074 (13.36)	.633 (8.08)	.562 (7.61)	.432 (6.08)	.227 (3.78)			26.83	1.11
324	187	-210.17 (2.39)	.892 (3.85)	.0017 (1.79)	.824 (14.76)	.019 (0.34)	.132 (2.41)	.116 (2.60)	.187 (4.31)	.148 (3.50)	.071 (1.05)	60.32	1.10
324[b]	185	-4.87 (0.02)	1.587 (5.22)	-.0173 (12.94)	1.074 (17.91)	.540 (9.91)	.411 (9.03)	.259 (7.57)	.238 (8.32)	.110 (5.03)	.008 (0.26)	33.97	1.62

(t-statistics are in parentheses)

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

[b] Estimated under the assumption if first order serial correlation of the error terms. Estimate of the serial correlation coefficient is .986.

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