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Special Article

in

QUARTERLY
ECONOMIC
COMMENTARY

December 1977

J. DURKAN
J. G. KEENAN

ESRI

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by

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1. *Introduction*

Macroeconometric models pay particular attention to the equations dealing with the major components of aggregate demand, such as consumption, investment and exports. In the Central Bank's econometric model [1], investment is broken down into three components: residential investment, non-residential investment and stockbuilding. While stockbuilding is a relatively small proportion of aggregate demand, it is a volatile magnitude and has traditionally been accorded an important place in the study of economic fluctuations. This note is devoted to a discussion of the stockbuilding equation. The following sections deal with the models tested, the empirical results and the conclusions. Data, sources and methods are given in the appendix.

2. *The Models Estimated*

The data series constituting the dependent variable in the equation for inventory change refers to total non-agricultural stocks, the magnitude which appears in the National Income and Expenditure accounts. This includes stocks of raw materials, work in progress and finished goods, both imported and domestically produced, in the hands of both producers and distributors at various levels. The data is therefore highly aggregated and, since we can only obtain annual observations, there is a high degree of time aggregation as well. The determinants of inventory change are likely to differ as between different types of stocks so the aggregation level of the data is unfortunate. Thus, the models tested are all variants of the simple partial-adjustment model; more complicated models could be attempted if disaggregated data were available.

Acknowledgements: The author would like to thank several commentators on an earlier draft, especially Joseph Durkan, Robert Kelleher, Kieran Kennedy and Brendan Walsh. The customary disclaimer applies.

The general structure of the partial adjustment model used has two equations.

$$S_t^* = a + bP_t \tag{1}$$

The first equation relates desired end-period stocks S_t^* to a variable P which is a proxy for expected sales. A number of alternative measures of P will be examined.

There are many alternative ways in which equation (1) could be specified. The opportunity cost of holding stocks varies and so does the productive capacity of firms. The equation need not, of course, be linear in its arguments. A discussion of the determinants of inventory investment will be found in Moriguchi [7] and we will return to some of these questions below.

$$S_t = S_{t-1} + \lambda(S_t^* - S_{t-1}) \tag{2}$$

The second equation is the adjustment equation and states that the actual change in stocks equals a fraction (λ) of the divergence between the desired end-period stock level (S_t^*) and the beginning-period stock level (S_{t-1}). If stocks were adjusted fully to desired levels within one year, the value of λ would be unity.

The estimating equation is obtained by substituting out the unobservable S^* variable to give

$$\Delta S_t = \lambda a + \lambda bP_t - \lambda S_{t-1} \tag{3}$$

This equation could be estimated by ordinary least squares if the right-side variable were exogenous. This may not be the case for some measures of P and an alternative technique is then required. Since equation (3) has three parameters, the coefficient estimates imply uniquely the values of the structural parameters in equations (1) and (2).

3. *Empirical Results*

Three variables have been used to proxy expected sales, GNP, Non-Agricultural GNP and Final Demand. In addition, some simple discrete lags in these variables were experimented with.

Using GNP, which we call Y, as the proxy for sales, gives the model:

$$S_t^* = a + bY_t \tag{4}$$

as the first equation. If a one-period lag is specified as well, we would have

$$S_t^* = a + bY_t + cY_{t-1} \tag{5}$$

We will call these models A and B. Substituting into the adjustment equation gives the reduced form, for model A, as:

$$\Delta S_t = \lambda a + \lambda b Y_t - \lambda S_{t-1} \tag{6}$$

Model B has an additional term in the reduced form. Since ΔS is a component of Y, indirect least squares is the appropriate estimation method. The results are given in Table 1.

TABLE 1. ESTIMATES USING THE GNP VARIABLE

Model	Coefficient Estimates				R^2	DW	T
	Intercept	$Y_t - \Delta S_t$	Y_{t-1}	S_{t-1}			
A 1953-'75	23.88 (12.75)	0.107 (0.03)	—	−0.544 (0.16)	.39	2.44	−2.87
B 1954-'75	23.97 (12.87)	0.188 (0.09)	−0.074 (0.10)	−0.586 (0.20)	.45	2.78	−3.64

The figures shown in brackets beneath each coefficent estimate are the sample standard errors, R^2 is the coefficient of determination and DW the Durbin-Watson ratio. Since DW is not an appropriate autocorrelation test, due to the presence of the lagged dependent variable, the Durbin t-test, which involves an auxiliary regression, was also undertaken. The final column in the Table gives the value of this test statistic.[1]

Model B gives slightly higher explanatory power than model A but both exhibit negative first-order serial correlation. In terms of the structural equations, model A implies that the coefficient b, which measures the impact effect of a rise in GNP on stock levels, is 0.2. The λ parameter is 0.5, which measures the speed of adjustment to discrepancies between actual

[1] The variant of Durbin's test used here involves the regression of the OLS residuals on the full set of explanatory variables with the addition of the lagged residuals. The hypothesis of no autocorrelation then reduces to a t-test (asymptotically) on the coefficient of the lagged residual. See Durbin [3] or the summary in Johnston [5].

and desired stocks. This value implies that one-half of the discrepancy is eliminated inside the year. For model B, the adjustment parameter is almost identical but the b coefficient is higher at 0.32.

Since the dependent variable relates to non-agricultural stocks, a variable measuring non-agricultural GNP might be deemed more appropriate than total GNP. Such a variable can be constructed for the period from 1958 onwards and the models were also estimated using this variable. The results, in terms of explanatory power, were slightly better than those using total GNP, but the best fits were obtained using the final demand variable. These results are given in Table 2.

TABLE 2. ESTIMATES USING THE FINAL DEMAND VARIABLE

Model	Coefficient Estimates				R^2	DW	T
	Intercept	$FD_t - \Delta S_t$	FD_{t-1}	S_{t-1}			
A 1953-'75	57.74 (16.20)	0.068 (0.02)	—	−0.590 (0.142)	.50	2.66	−3.24
B 1954-'75	60.69 (15.73)	0.087 (0.02)	−0.013 (0.008)	−0.647 (0.142)	.56	3.04	−4.09

Aside from the higher R^2 values, the pattern of results is similar to those exhibited in Table 1. The adjustment parameters are 0.55 and 0.60 respectively, for models A and B, while the slope coefficients (on FD_t) are 0.11 and 0.14. These are lower than was the case with the GNP models, but, of course, final demand is a larger magnitude than GNP, so we would expect slope coefficients to be scaled downwards. Final demand might be expected to proxy sales better than GNP, which is more of an income concept. The negative coefficient on the lagged variable indicates that expectations of sales are formed as a positive function of current final demand and as a negative function of the previous level of final demand. Thus, there is a regressive element in expectation formation.

Both of the equations in Table 2 exhibit negative first-order serial correlation, as was also the case with the GNP models. Using a maximum likelihood search, the values of the first-order autocorrelation coefficient and the implied structural parameter values are given in Table 3.

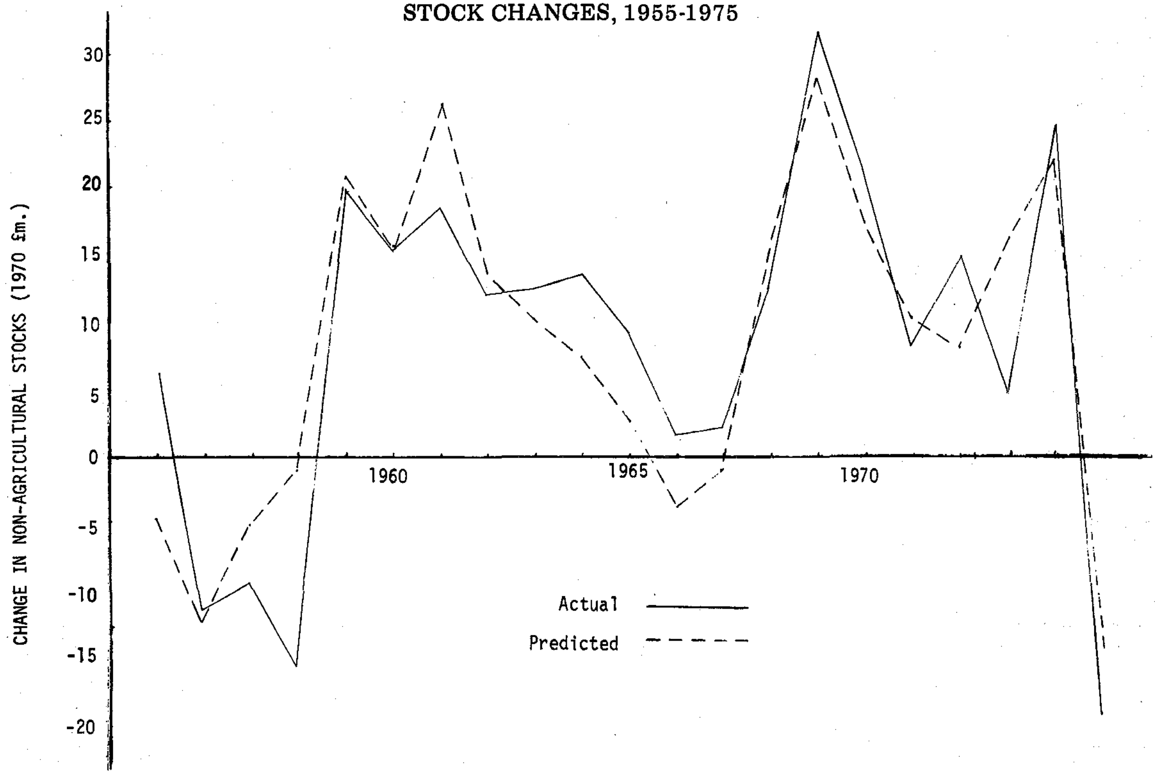
TABLE 3. ESTIMATES OF THE FINAL DEMAND MODEL WITH AUTOCORRELATION CORRECTION

Model	Slope Coefficient	Adjustment Parameter	Autocorrelation Coefficient	R^2	DW
A 1954-'75	0.117	0.61	−0.66	0.74	1.52
B 1955-'75	0.142	0.61	−0.80	0.78	1.83

The slope coefficients shown in Table 3 are almost identical with those derived from Table 2 but the adjustment parameters are a little higher. The coefficients of determination shown in the Table take the lagged residuals into account and are substantially higher than before. The autocorrelation coefficients are both quite large, suggesting that the model specification may be incomplete.

The performance of the second (B) model using the final demand variable is illustrated in Figure 1.

FIGURE 1. ACTUAL AND PREDICTED VALUES OF NON-AGRICULTURAL STOCK CHANGES, 1955-1975



The extreme volatility of the stock-change series itself is evident from the figure, with swings from one year to the next exceeding 1% of GNP on occasions. Thus, even though the absolute size of the change in stocks is small relative to other GNP components, its variability makes it of comparable importance in studying fluctuations in economic activity.

The tracking performance of the equation (which is the autocorrelation-corrected B equation from Table 3) is superficially impressive, given the erratic time-path of the actual stock-change series. However, the equation fails to pick up several of the turning-points and its predictive power is partly due to the autocorrelation correction. Given the size of the first-order autocorrelation coefficient, it is likely that the equation is under-specified and the correction for autocorrelation may be deceptive as a result.

Since the full available data-run has been used in estimation, it is not possible to assess the extra-sample predictive performance of the model, which would clearly be desirable.

It was mentioned in section 2 that the desired stocks equation could be specified in a number of different ways. In addition to the results given in the tables, a number of other models were experimented with, aside from those using the non-agricultural GNP variable mentioned earlier. These concerned (a) the inclusion of a variable measuring the opportunity cost of holding inventories; (b) nonlinear forms of the desired stocks equation and (c) versions of the linear model with a one-period lag on GNP and no contemporaneous GNP term.

The opportunity cost variable was always insignificant, the nonlinear models gave results very similar to the linear ones and the exclusion of the contemporaneous GNP variable reduced the model's explanatory power considerably. These results are reported in detail in McCarthy [6].

4. *Summary and Conclusions*

In this note, an attempt was made to develop an econometric model of non-agricultural stock changes. A partial-adjustment model using current and lagged final demand to proxy sales expectations gave the best results but the equation was severely autocorrelated. Making an adjustment for autocorrelation yields a model which gives a satisfactory within-sample tracking performance, although turning points are not always picked up.

The estimates imply that an increase in final demand will cause desired stock levels to rise by approximately 14% of the rise in demand. Adjustment to the new equilibrium is reasonably rapid with over 60% of the adjustment taking place within the year.

The equation appearing in the current version of the Central Bank's macroeconometric model is not quite the same as that developed here and does not track the data as closely. It will be replaced when the next version of the model is prepared.

Writers on inventory investment have commonly employed a three-way breakdown into stocks of raw materials, work in progress and finished goods. Raw material stocks will depend on production intentions, work in progress on current levels of activity and stocks of finished goods on demand conditions. There may be speculative factors at work as well, particularly in the case of raw material stocks where there can be considerable uncertainty about the future course of prices.

If disaggregated data were available, it would be desirable to model these components of stock changes separately. The level of time-aggregation is also a problem and, as with any area in which time-lags are important, sub-annual data would be more revealing than the annual figures presently available.

APPENDIX — DATA, SOURCES AND METHODS

Stock-adjustment models involve lagged stock *levels* as arguments in the estimating equations, even though the change in stocks is the dependent variable. In order to estimate these models a series on the level of stocks must be constructed, since no published figures are available.

The method used here is to benchmark the stock level in 1947 and to form the stock series by accumulating the (known) change in stocks figures for later years. The figures for non-agricultural stock changes are available in the national accounts (National Income and Expenditure) volumes back to 1953. For earlier years, an unpublished series kindly made available by Kieran Kennedy of the ESRI has been used. Stock changes arising from agricultural intervention since EEC membership have been removed for the last few years of the data period, using information supplied by the Department of Finance. The figures have been re-worked to a 1970 base.

TABLE A1. RATIOS OF THE CHANGE IN STOCKS TO THE CHANGE IN GNP

Period	$\Delta S/\Delta GNP$
1970-74	.28
1965-74	.21
1960-74	.24
1955-74	.21
1950-74	.20
1947-74	.23

The ratio of ΔS to ΔGNP shown in Table A1 seem reasonably stable, although on a year-to-year basis they fluctuate considerably. The benchmark figure for 1947 was obtained by setting the ratio at .23 for that year. The other series used in the regressions are for the change in non-agricultural stocks itself, for GNP, for non-agricultural GNP and for final demand. Both the GNP and final demand figures are taken directly from the Central Bank of Ireland's data bank [2], while the non-agricultural GNP series is obtained by subtracting agricultural GDP (from the National Income and Expenditure volumes again) from total GNP. All of the series used in the regressions are given in Table A2.

TABLE A2. TIME-SERIES DATA, 1952-1975.
(All figures are in £m. at constant 1970 prices)

Year	Change in Non-Agricultural Stocks	Level of Non-Agricultural Stocks	Gross National Product	Final Demand	Non-Agricultural GNP
1952	—	259.8	—	—	—
1953	1.1	247.6	1002.8	1256.0	—
1954	—3.4	248.8	1011.8	1259.4	—
1955	6.4	245.3	1041.0	1318.0	—
1956	—11.2	251.8	1020.0	1259.4	—
1957	—9.3	240.6	1019.0	1245.3	—
1958	—15.6	231.3	1006.1	1257.3	821.2
1959	20.0	215.7	1046.1	1323.7	844.4
1960	15.4	235.7	1097.9	1389.9	886.5
1961	18.6	251.1	1151.5	1484.4	938.0
1962	11.9	269.7	1192.8	1545.6	977.6
1963	12.4	281.6	1248.4	1642.5	1036.9
1964	13.6	294.0	1300.7	1755.4	1079.5
1965	9.2	307.6	1334.0	1808.6	1121.0
1966	1.7	316.8	1349.8	1844.8	1137.1
1967	2.1	318.5	1418.4	1931.6	1199.9
1968	12.6	320.6	1536.3	2128.6	1304.8
1969	31.8	333.2	1621.9	2303.5	1395.2
1970	21.2	365.0	1671.0	2371.2	1438.1
1971	8.1	386.2	1730.3	2463.0	1482.4
1972	14.9	394.3	1828.0	2606.2	1567.4
1973	4.8	409.2	1898.7	2844.0	1637.6
1974	24.6	414.0	1932.3	2862.7	1658.7
1975	—19.0	438.6	1928.0	2760.0	1622.0

Since the stock level series has had to be approximated, it is of interest to cross-check its level against completely independent information, and such a cross-check is in fact possible. In an article in the Quarterly Economic Commmentary in 1973 [4], R. C. Geary reports the findings of a pilot study on stock levels. His figures are based on a sample of establishments in transportable goods industries and in wholesale and retail distribution. This covers the bulk of "non-agricultural" leaving out only construction, fuel and power and services. Geary's figure for end-1969 was £301.4m. at current prices. Our figure for the same date and at the same prices is £365m., larger than Geary's figure as it ought to be. Whether it corresponds precisely is impossible to say, but these two, completely independent, estimates are certainly compatible.

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