Inventory Behavior and Economic Instability in Japan

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Introduction

Fluctuations in inventory investment are becoming recognized as a major mechanism by which business cycles in the U.S. and Western Europe may be propogated. While not always the source or cause of recent recessions, inventory fluctuations may be a principal mechanism by which a disturbance or shock is spread throughout the economy. For the U.S. and the large European economies production has been shown to be more unstable than final sales (gross product minus the change in aggregate inventories stock).[1] Thus fluctuations in inventory investment do not appear to be offset by changes in production.

Two principal explanations for this phenomena have been forthcoming. The production smoothing model of inventory investment is valid, however, producers face declining marginal costs. Secondly, inventories do buffer production but from cost rather than demand shocks (intertemporal substitution of production resulting from shocks to wage and raw material prices).[2]

Attempts to subject these hypotheses concerning inventory behavior to empirical testing have seen only limited success.[3] For the United States, it has been shown that intertemporal prices or the "user cost" of inventories are important in explaining the behavior of some types of inventories in certain time periods. The evidence for "cost shocks" is even more limited. On the other hand, for the larger European economies, the behavior of aggregate inventories does not seem to be explained by these variables.

The purpose of this paper is to analyze whether or not the behavior of Japanese inventory investment is consistent with the U.S. and W. European experience. The behavior of Japanese inventory investment could differ due to such factors as industry inventory management techniques (the "just in time" system), the relative influence of demand versus cost shocks, the relation between the level of output and the convexity (and or concavity) of the production function[4], and the ability of Japanese firms to successfully backlog unfilled demand[5].

The next section of this paper examines the contribution of inventory investment to economic instability in Japan and compares the results with the U.S. and four large European economies. Section 3 specifies a general model of inventory investment and presents estimates of the model for Japan. The final section contrasts the results of this study with those for other countries and summarizes the principal conclusions.

2. Inventory Behavior and Economic Instability in Japan

Although inventory investment in N. America and W. Europe during the postwar years accounts for only 0.7 to 1.5 percent of gross product, it may be a significant part of business and growth cycles. For example, the average inventory change was 68 percent of the average GNP decline during the eight postwar U.S. recessions. Blinder (1981), Blinder and Holtz-Eakin, Hillinger, and Wilkinson (1989) provide additional evidence for the importance of inventory changes for economic fluctuations in N. America and W. Europe.

What is the evidence for Japan. Table 1 exhibits some measures of the relative size of inventory investment, the variability of real product, and the contribution of inventory investment to economic instability for Japan, U.S., Canada, and four large European economies. For Japan, inventory investment is almost 2 percent of GDP -- a figure that exceeds that of all the other six industrial economies (column 3). The next column (4) exhibits a measure of the variability of real gross product as an indication of the degree of economic instability experienced by Japan and the other six economies. In terms of both the relative significance of inventory investment and economic instability, Japan is an outlyer with regard to the experience of this group of major industrial economies.

The final column in table 1 is a measure of the contribution of inventory investment to economic instability. It reflects how much more unstable is production than final sales (gross product minus the change in aggregate inventory stock). If inventory change is destabilizing the measure is always positive. If inventory change has a stabilizing effect, the measure is negative.[6] As judged by this simple measure, the destabilizing effect of inventory change in Japan is greater than for the U.S., Germany and Canada but less than the U.K., Italy and France. For Japan, on average production was 30 percent more unstable than sales. Germany experienced the least destabilizing effects of inventory behavior. The figures for Italy and France partly reflect the shorter samples. For France a greater weight and for Italy the total weight is given to the decade of the 1970s -- a decade characterized by more economic instability than the 1960s. In short, the behavior of aggregate inventories as a possible propogation mechanism for economic instability does seem to characterize Japan as well as some other major industrial economies in N. America and W. Europe.

3. Functional Specification and Estimation

Since the 1950's a number of inventory models and hypotheses have been proposed. This literature is briefly reviewed in Wilkinson (1989). Fundamentally, this literature identifies four sets of factors that influence or explain inventory investment: (1) anticipated and unanticipated changes in sales; (2) intertemporal prices or the user cost of inventories; (3) prices of other inputs used in addition to inventories; and (4) other variables such as lagged values of the stock of inventories and capacity utilization.

In this study a general or flexible distributed lag model is adopted that nests many of the specifications discussed in the previous section. Specifically,

$$\Delta n_t = \alpha_o + \alpha_1 Z_t + \alpha_3 n_{t-1} + u_t, \tag{1}$$

where Δn_t is the change in aggregate stocks of inventories and Z_t are explanatory variables such as sales, intertemporal prices (nominal interest rates and inflation), input prices (labor and raw materials) and the rate of capacity utilization. The set of explanatory variables changes as individual hypotheses are analyzed. In addition to estimating a version of (1) an alternate specification is investigated,

$$\Delta n_t = \beta_o + \beta_1 Z^*_t + \beta_2 (Z_t - Z^*_t) + \beta_3 X_t + \beta_4 n_{t-1} + e_t, \tag{2}$$

Where Z^*_t is the expected or anticipated and $(Z^*_t - Z_t)$ the unanticipated component of Z_t. In this specification Z_t includes sales, the rate of inflation, and input prices. Inventory models with sales expectation formation in a weak or partly rational manner have recently been estimated by Blinder (1984, 1986) and Trivedi (1970, 1973), among others. Here we extend the full rational expectations hypothesis to specifications including intertemporal prices and relative input prices.

In order to estimate eq. (2), the unobserved expectations must be generated by an auxiliary specification. A standard approach is to generate one-period-ahead forecasts from a vector autoregression (VAR). We employ two lags of Δn and each Z and X variable. Z^* is the predicted value and $(Z-Z^*)$ the residual from the VAR.

The VARs are estimated by OLS and the anticipated and unanticipated series are used in an OLS estimate of eq. (2). The VARs fit the data quite well with the exception of the inflation rate. The R^2 for the other variables exceeds 0.98 but for inflation it is generally below 0.70.

This two-step estimation procedure results in correct estimates for the standard errors of unanticipated variables but incorrect estimates for the anticipated variables. Correct estimates of the latter are obtained from a TSLS estimate of (2) with (Z*-Z) omitted and the explanatory variables for the VAR used as the first stage (Pagan).

A set of diagnostic or specification tests were undertaken for each pair of hypothesis in order to evaluate the adequacy of the model. These include the Durbin-Watson test (biased due to the presence of the lagged inventory stock in each regression), the Box-Pierce Q statistic, Harvey's (1981) version of the LM test for rth (r=6) order residual autocorrelation (likely to have low power), the corrected autocorrelation function (McAleer, Pagan and Volker), Chow's test for parameter constancy (an F test of OLS regressions over the first three quarters of the sample and the full sample), Engel's first order ARCH test for autoregressive conditional heteroscedasticity, and Ramsay's RESET test (the F test that the coefficients of the predictions squared and cubed in the regression of the residuals against these and the derivatives are zero). Finally, the 'real interest rate hypothesis' is tested, i.e., that the nominal interest rate and anticipated rate of inflation (or actual inflation in eq. (1)) have coefficients of equal absolute value but opposite signs.

4. Empirical Results

The various models are estimated using quarterly and seasonally adjusted data for Japan. The individual data series are discussed further in the Data Appendix. Table 2 presents six regressions and associated summary statistics. The first pair of regressions incorporate hypotheses concerning sales and intertemporal prices. The second pair brings in relative input prices and the final pair adds capacity utilization to the set of regressors. The latter variable has been shown to be an important part of the explanation of the behavior of U.S. aggregate inventories (Akhtar). It can be interpreted either as evidence of production smoothing (a negative coefficient) or as 'positively related to unintended changes in inventories' (Akhtar, 322).

Finally each pair of regressions contains versions of eqs (1) and (2). While the decomposition of variables into anticipated and unanticipated components is quite standard, it is also open to question. Hence, a more standard model is also estimated for each set of hypotheses.

The most familiar inventory model is a specification incorporating the lagged inventory stock, sales, and intertemporal prices (regressions 1 and 2 in Table 2). The speed of adjustment of the stock of inventories implied by the estimated coefficient for the lagged inventory stock is quite reasonable. Within one quarter, 53 to 58 percent of the difference between actual and desired inventories is closed. This contrasts with the usual result reported in the literature that one year is required to complete 50 percent of the adjustment (Blinder, 1986a). Anticipated sales is significant with the expected sign but not unanticipated sales. While the nominal interest is statistically significant it does not exhibit the expected sign. The hypotheses that only the real interest rate matters (i.e., the signs on the nominal interest rate and anticipated inflation -- actual inflation in the no-surprise regression (2) -- have equal and opposite coefficients) is rejected. Finally, the residuals from this model are not white noise -- as evidenced by the Durbin and Watson statistic and other tests that were undertaken --, however, no other model inadequacies were uncovered by the remaining diagnostic tests.

The next pair of regressions (3-4) add the hypotheses concerning input prices. While the estimated adjustment speed is still acceptable, input prices are insignificant, all sales variables are now insignificant, the nominal interest continues to exhibit the wrong sign, and the residuals are not white noise. This model is clearly not an improvement over the basic inventory model in regressions (1-2).

The final pair of regressions (5-6) incorporates the hypotheses concerning capacity utilization. The latter has received the least attention in empirical studies, however, it is statistically significant in regressions for the U.S. and several W. European economies (Akhtar, Wilkinson, 1989). Regressions (5-6) display a substantial improvement in fit (as judged by the usual F tests), the serially correlated residuals are eliminated, unanticipated sales are statistically significant and the negative sign indicates that they are met out of inventories, the nominal interest rate is significant and displays the expected sign, and capacity utilization is highly significant. Unfortunately, the coefficients on the lagged inventory stock and anticipated sales while significant have the wrong signs.

Conclusions

The above results do not explain a great deal about the behavior of aggregate inventories in Japan. There is no evidence that cost shocks (to labor and raw materials) are part of the story. Nominal interest rates are only significant with the expected negative sign in our third model (5-6). Additional inquiry is required to explore the role that the rate of capacity utilization is playing in inventory models, and in particular, why inclusion of this variable results in an implausible estimated coefficient for the lagged inventory stock (and the speed of inventory adjustment).

On the other hand, unless the aggregate inventory data is unsatisfactory for Japan (see footnote 2, above) inventory investment does seem to be an important propogation mechanism for economic instability.

Data Appendix

All data series are from Quarterly National Accounts of OECD Countries and Main Economic Indicators published by O.E.C.D., Paris, and maintained by the I.P. Sharp database and Nihon Tokei Geppo. The data on real inventory stocks are from the Economic Statistics and National Accounts Division of O.E.C.D. The individual series are as follows: Sales is real aggregate sales of goods (NIPA basis); nominal interest rates are call money rates; and inflation is the quarterly percentage change in wholesale prices; input prices are real hourly wages in manufacturing and real raw material prices; capacity utilization is the rate of industrial capacity utilization. The sample period appears at the head of table 2.

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Footnotes

1. See Blinder (1981) for a review of the importance of inventory changes in U.S. business cycles. Wilkinson (1989) presents results for the United Kingdom, France, Italy, and W. Germany.

2. Recently an additional explanation has been put forth. Miron and Zeldes and Fair contend that U.S. data on inventories and production are not compatible. Questionable data may be confusing the issues.

3. Blinder (1981) and Wilkinson (1989) briefly review a number of the recent empirical studies of inventory investment.

4. The level of output at which cost curves are declining or U shaped can give rise to substantial changes in production due to demand shocks.

5. With backlogging, the production smoothing model does not necessarily imply that the variance of sales must exceed that of production (Kahn).

6. See DeLeeuv for further discussion of this and other measures of the contribution of inventory investment to instability.

Table 1

RELATIVE SIZE OF INVENTORY INVESTMENT, VARIABILITY OF OUTPUT AND CONTRIBUTION OF INVENTORY INVESTMENT TO ECONOMIC INSTABILITY

	Mean Output[a]	Mean Inventory Investment	(1)/(2)	Variability of Output[b]	Contrib. of Inventory to Instability[c]
Japan 53.4 - 82.1	63595.04	1187.63	0.0187	2.09	29.9
U.S. 59.1 - 81.4	1108.43	8.35	0.0075	1.82	20.8
Germany 57.3 - 81.3	224.35	2.20	0.0098	1.88	12.6
Canada 52.3 - 81.2	81185.71	525.0	0.0065	1.83	26.2
U.K. 57.3 - 81.2	46271.29	290.61	0.0063	1.72	35.1
Italy 70.1 - 82.4	18780.94	288.40	0.0154	2,67	55.8
France 65.3 - 81.2	220.15	3.25	0.0148	1.48	49.3

Notes to Table 1

[a] Real GNP for U.S. and real GDP for the remaining countries

[b] Standard deviation of the quarterly percentage change in output

[c] $100\left(\frac{g-s}{s}\right)$ where g is the square root of the mean square percent deviation from trend of output and s is the same measure for real final sales. Trend is a 21-quarter centered moving average