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ABSTRACT

This paper compares the cyclical and secular behavior of Japanese and U.S. inventories at the aggregate and sectoral level, 1967-1987. While, as is well known, U.S. inventories are sharply procyclical, Japanese inventories are only mildly procyclical. In neither country do inventory and sales move together in the long run, in the sense that the two series do not seem to be cointegrated. In Japan, but not in the U.S., there is a secular decline in the inventory-sales ratio.

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This paper compares the cyclical and secular behavior of Japanese and United States inventories, 1967-1987. Using data both at the aggregate level and disaggregated to the manufacturing and wholesale sectors, it finds that Japanese inventories are at best mildly procylical, and perhaps could even be characterized as acyclical; it is well known that, by contrast, U.S. inventories are sharply procyclical (e.g., Blinder (1981)). It also finds that in both countries the secular movements of inventories and sales (or of inventories and output) do not seem to be tightly linked in that the two are not cointegrated. In Japan, but not in the U.S., there is a secular decline in the inventory sales ratio as well. The decline is especially large for raw materials inventories in manufacturing.

The aim of this paper is to document these facts. Since interpretation and explanation is largely left for future work, it may help here at the outset to motivate the data analysis by noting that these findings have implications for business cycle theories. In standard models, inventories serve to buffer production; in a general setup such as I have in mind, they buffer both demand and cost shocks.[1] West (1990b) argues that cost shocks tend to cause procyclical movements in inventories, demand shocks countercyclical movements. Inventory movements being markedly less procyclical in Japan suggests a relatively less important role for cost shocks; a model in which the business cycle is driven largely by cost shocks (e.g., Prescott (1986)) therefore probably is less appealing for Japanese than for U.S. data. West (1990b) also argues that if inventories and sales do not appear to be cointegrated it is inadequate to assume that the long run behavior of both variables is driven by a single type of shock, whether demand (e.g., Holt et al. (1960)) or cost (e.g., Christiano (1988)); instead, persistence in both cost and demand shocks appear to be suggested.

One caution is in order, before beginning the analysis. The sectoral data for Japan may well not be very accurate. For this reason that I concentrate on the qualitative characteristics of the data. I do not specify and estimate a precise model, and, for the most part, do not calculate standard errors.

Section II discusses data, section III presents empirical results.

II. Data

All data used in the calculations presented below were real, quarterly and seasonally adjusted, 1967:1 to 1987:4. The base year for U.S. data is 1982, for Japanese data is 1980. Data were obtained for inventories and sales for the entire economy, as well as for the wholesale and manufacturing sectors. These two sectors account for over half of total inventories in both countries, and, in the U.S., are among the most cyclically sensitive (Blinder (1981)). Consideration of retail inventories would also be of interest, but I have been unable to obtain adequate Japanese data on these.

CITIBASE was the source for the U.S. data. Real, quarterly data included real GNP (GNP82), final sales (GNS82), and the level of manufacturing (GLM82) and merchant wholesaler (GLW82) inventories. Real, quarterly sales figures were computed by (1) selecting the inventory-sales ratios for the last month of each quarter (IVSRM8 and IVSRW8) and (2)dividing the corresponding real inventory figure by this ratio. Monthly nominal data on manufacturing inventories by stage of manufacturing (IVM, IVM1, IVM2, IVM3) were converted to quarterly real series by (1)selecting the last month of each quarter and (2) deflating by the ratio of real to nominal inventories in manufacturing as a whole.

Japanese data came from several sources. The original source is in English except when otherwise stated. Basic quarterly national income data for real GNP, final sales and aggregate inventory investment came from the OECD's Main Economic Indicators (MEI) as supplied on diskettes by VAR Econometrics. A series for the level of the aggregate inventory stock was constructed by combining the 1980:4 figure for the stock (Economic Statistics Annual 1987, p349) with the MEI figure for inventory investment. These inventory data appear to be comparable in quality to U.S. data. They reflect, for example, changes in accounting procedures (e.g., LIFO vs. FIFO), and are benchmarked against survey data every month (OECD, 1979).

Monthly, seasonally unadjusted data on the wholesale price index (WPI) and the WPI in manufacturing were obtained from the Annual Report on Business Cycle Indicators (1975, 1987). These were rescaled to a common base year (1980=100). Quarterly, seasonally adjusted series were constructed by (1)regressing the log of the rescaled monthly series on a quadratic time trend and twelve monthly dummies; (2)computing the fitted value implied by the quadratic trend plus the mean of the monthly dummies; (3)exponentiating this fitted value, and (4)averaging the monthly figure to get a quarterly figure.

All sectoral data on inventories and sales were obtained from the Ministry of Finance's Statistical Survey of Incorporated Enterprises.[2] This survey covers all firms capitalized at over 10 million yen. The data in the survey come directly from the balance sheets of the firms. The sample changes in the second quarter of each year, when the list of firms of the requisite size is updated. I made no attempt to smooth or otherwise adjust for the change in sample. The raw inventory and sales data were seasonally adjusted as above. The manufacturing data were then deflated by the manufacturing WPI, the wholesale data by the WPI.

There are obvious potential problems with these data. One is that the inventory figures are based on book values, with no inventory valuation adjustment, and no adjustment for trends in accounting rules (LIFO vs. FIFO, etc.) It is difficult to get a sense for how much measurement error is thereby introduced. Perhaps some indirect evidence that the bias is not large is the comparison in West (1990a) between (1)U.S. real inventory investment, carefully deflated by the Department of Commerce, and (2)a real inventory investment series constructed simply by deflating the nominal national income figure by the GDP deflator. For annual data, 1957-1986, the two series were highly correlated (correlation coefficient - .9931) and seemed to interact with GNP in very similar fashions. Whether the biases in Japanese data are similarly small I do not know, but this calculation at any rate does not argue that the use of appropriately deflated data would lead to substantively different results.

Probably much more troublesome are two potential problems from the coverage of the survey which, as stated above, changes every year. The seasonal adjustment described above may well not adequately capture this variation. In addition, by omitting small firms these data may give a distorted picture of the behavior of the sector as a whole.

To get a sense for the potential importance of these biases, I obtained economy wide data on Japanese inventories from various issues of the Japan Statistical Yearbook. (Apart from using the 1980 figure to anchor the level of the aggregate stock, I did not use these data in the main body of this paper because I was unable to locate any but annual figures [the first quarter of every calender year], and those just for inventories.)

My data for aggregate inventories comes from this source and thus is complete (Table I, panel A, column (1)). The data for the U.S. of course are complete for all sectors (panel B). But the remaining Japanese data come from the Survey and so are incomplete. As indicated in columns (2) and (3) in panel A, small firms account for a small or declining fraction of total inventories in each sector. (The fraction declines because inflation and real growth both serve to push firms above the threshold required to appear in the Survey.) Unfortunately, the fraction of wholesale firms included has grown sharply, potentially introducing unknown biases.

Table II has the means and standard deviations of the data, where H denotes inventories, S sales. In both countries, about half of aggregate inventories are in manufacturing, about one sixth in wholesale; each of the three stages of fabrication account for about one third of the manufacturing stock (column 2, panels A and B).

In each country the aggregate stock is roughly the size of the quarterly flow of sales (row 1, column 1 and 2, panels A and B). But at the sectoral level there are dramatic differences in the relationship between levels of stocks and sales, with the means in columns 2 and 3, rows 2 to 6 implying Japanese inventory sales ratios that are perhaps one third of the ratios in U.S. manufacturing, one sixth of that in wholesale: while the sectoral inventory figures bear the same relation to the aggregate figures in both countries, the Japanese sales figures are much larger relative to the aggregate. Indeed, Japanese sectoral sales add up to far more than the total (panel A, column 2, rows 1, 2 and 6). While this is logically possible--the aggregate figure is for final sales, the sectoral figures are not--the dramatic contrast with the U.S. numbers suggests that the sectoral sales data may not be comparable across countries. In the analysis below, therefore, especially heavy weight should be placed on the aggregate data.

III. Empirical Results

A. Cyclical Comparisons

Here I examine (1)the behavior of aggregate inventories during cyclical downturns, and (2)the relative variability of production and sales, at both the aggregate and sectoral levels.

(1) In the Annual Report on Business Cycle Indicators, the Japanese Economic Planning Agency has identified five recessions in the 1967-1987 period. It appears that it is the change rather than the level of real GNP that is considered a coincident indicator in Japan: the recession after the first oil shock was the only one in which real GNP was lower at the trough than the peak. If a question of interest for U.S. business cycles is the contribution of changes in inventory investment to changes in GNP, the comparable question for Japanese business cycles would seem to involve the contribution of changes of changes of inventory investment to changes of GNP.

This is summarized in Table III, where Q denotes GNP and H aggregate inventories. As in Blinder (1981), I look at peaks and troughs of GNP (U.S.) or changes in GNP (Japan) rather than official business cycle peaks and troughs. Changes of changes of inventory investment contribute only modestly to recessions in Japan, typically accounting for only about 10 percent of the fall in changes in GNP (panel A, column (6)).[3] As is well known (Blinder (1981)), changes in inventory investment usually figure prominently in U.S. recessions, typically accounting for about 50 percent of the fall in GNP (panel B, column (6)).

(2) Let Q_t be production, S_t sales, H_t inventories. The variables are linked by the identity $Q_t = S_t + H_t - H_{t-1}$. The notion that inventories move pro- or countercyclically can be formalized in many ways. I test the null of countercyclical movement with three inequalities that have been suggested in previous work on U.S. inventories:

(1a) $var(\Delta Q_t)/var(\Delta S_t) < 1$,

(1b) $E(S_t \Delta H_t) < 0$.

(1c) $E(Q_t^2 - S_t^2) < 0$,

In (1a)-(1c), "var" denotes variance, "E" denotes mathematical expectations, and the variables are assumed to have zero means. The three inequalities are suggested by a model in which inventories buffer production from demand shocks. The reverse inequalities are suggested if inventories buffer cost shocks (West (1990b)).

Inequality (1b) directly focuses on countercylicality, saying that, on average, when demand (S_t) is high, inventories will be decumulated (ΔH_t will be low); the converse will hold when demand is low. Inequalities (1a) and (1c) reflect the stronger notion that production is, on average, less variable than demand, when demand shocks are the driving force behind the cycle. Note that because $E(Q_t^2 - S_t^2) = 2E(S_t \Delta H_t) + E(\Delta H_t^2)$, (1b) is necessary (but not sufficient) for (1c). Theses inequalities are valid even in the presence of unit autoregressive roots (West (1988)). See West (1986, 1988) for further discussion.

In columns (2), (3) and (5) in Table IV are empirical estimates of the left hand sides of (1a), (1b) and (1c). Columns (4) and (6) are presented solely to scale the entries in columns (3) and (5). For the aggregate economy, Q_t was measured as real GNP. Otherwise, Q_t was constructed as $Q_t = S_t + H_t + H_{t-1}$, with manufacturing H_t the sum of finished goods and works in progress inventories. Columns (3) and (5) were calculated as described in West (1988) so that the figures would be legitimate in the presence of unit roots.

In panel B, all three inequalities suggest here as in many previous studies that U.S. inventories move procyclically, in all three data sets. In Japan, there is mixed evidence. At the aggregate level, two inequalities are satisfied (panel A, line 1, columns 2 and 4), one is not (column 6), suggesting neither sharply procyclical nor sharply countercyclical movement. At the sectoral levels of manufacturing and wholesale, all three inequalities imply procyclical movement. But a comparison of the U.S. and Japanese figures in columns 2, 4 and 6 indicates that the tendency is much less pronounced in Japan.

I summarize the cyclical evidence in Tables III and IV as suggesting that Japanese inventories are at best mildly procyclical, perhaps even acyclical.

B. Secular comparisons

Here I examine (1)cointegration of inventories and sales, and (2)deterministic trends in inventory-sales ratios.

(1) I ran augmented Dickey-Fuller tests for unit roots in both the levels and differences of both inventories and sales, for the aggregate and sectoral data sets for both countries. The null of a unit root in the level but not in the difference looked reasonable for all series (details available on

request).

I then tested the null of no cointegration between inventories and sales using the augmented Dickey-Fuller test described in Engle and Granger (1987). (Note that since the change in inventories appears stationary, inventories and production are cointegrated if and only if inventories and sales are cointegrated.) For each of six pairs of inventories and sales, I regressed H_t on S_t and a constant, and also did the reverse regression. After each regression I did a Dickey-Fuller test on the residual, using four lags. The results are in Table V. None of the twelve t-statistics reject the null of no cointegration at the one percent level, although four do reject at the five percent level (manufacturing, Japan, both regressions, and wholesale, U.S., both regressions). Thus the data do not suggest cointegration between inventories and sales as a general rule. This is consistent with West (1990b), in which I also found two unit roots in the aggregate U.S. inventory and sales data using a longer sample period and a detailed Monte Carlo experiment.

(2) Figure I plots the aggregate inventory sales ratios. Table VI gives some statistics on these ratios, as well as the ratios in wholesale and manufacturing by stage of fabrication.

As a general rule, inventory sales ratios peak during recessions and decline during expansions. See the dates in columns 3 and 4 in both panels of Table VI. Thus the decline in both countries over the last few years that is evident in Figure I is not a surprise. But over the longer 1967-1987 period, we see from the figure and from column 5 in panel B that there has been no secular movement in any of the ratios in the U.S..

In Japan, by contrast, the figure suggests a sharp decline in the post-1974 part of the sample. The point estimates in column 5 of panel A indicate that the decline applies to aggregate inventories and to manufacturing inventories by all stages of fabrication. The decline is most marked in raw materials in manufacturing: the -.043 figure in column 5 implies that each year the ratio of raw materials to manufacturing sales declines on average by a little less than .2 percent (.2 ≈ 4 x .043). The standard errors on this and other estimates are, however, large, so we seem to need a longer sample to forecast the future behavior of these ratios with any confidence. Note that the aggregate data, which, as noted above, are probably the most reliable, yields the highest t-statistic, rejecting the null of zero change in the ratio at the 10 percent level.

Since the global minimum of these ratios tends to occur at the end of the sample, much of this secular decline may well be attributable to whatever tends to cause inventory-sales ratios to fall during expansions: by U.S. standards, at least, Japan has had an uninterrupted expansion since 1975. But the large rate of decline for raw materials suggests that the famous "just in time" system of inventory management (e.g., Cusimano (1985)) may be important as well. Sorting out the various factors that have caused the ratios to fall in Japan is an important task for future work.

I interpret Tables V and VI as suggesting that inventories and sales do not move together in the long run, in either country.

Footnotes

1. The reader familiar with the inventory literature will recognize this as a production smoothing model, which at first blush may seem inapplicable to Japan given the much discussed "just in time" system of inventory management (e.g., Cusimano (1985)). But even if such a model is ill suited to explain inventory holdings of a single firm (a debatable point, in my opinion), the Japanese economy, and sectors such as manufacturing, could be led by an invisible hand to act as if they were minimizing costs that increase in the fashion suggested by the production smoothing model.

2. Transliterated title in original: Hojin Kigyo Tokei Kiho Shoran. This title, as well as the headings in the tables in the Survey, were translated from the Japanese by Fukunari Kimura.

3. I am not sure how to reconcile these results with those of Kosai and Ogino (1984, pp21-22). They report that some pre-1967 cycles are almost entirely accounted for by inventories. They also find a large role for inventories in the 1973:4 to 1975:1 recession. Why my data are different from theirs for this recession I do not know.

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Figure I

Aggregate Inventory Sales Ratio

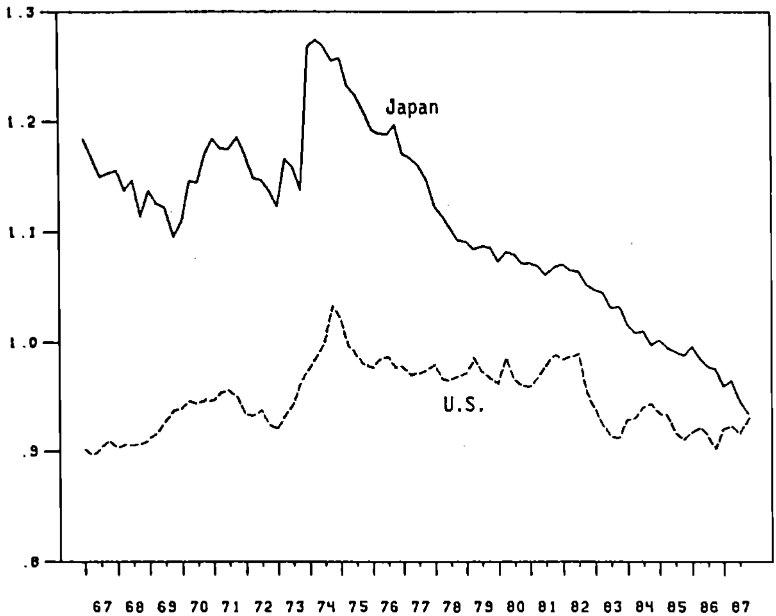

Table I

Percentage of Economy Wide Stocks Included in Data, Selected Years

A. Japan

	(1) Aggregate	(2) Manufacturing	(3) Wholesale
(1) 1970:1	100.0	89.98	66.53
(2) 1979:1	100.0	90.38	76.23
(3) 1987:1	100.0	89.27	85.83

B. United States

	(1) Aggregate	(2) Manufacturing	(3) Wholesale
(1) 1970:1	100.0	100.0	100.0
(2) 1979:1	100.0	100.0	100.0
(3) 1987:1	100.0	100.0	100.0

Table II

Means and Standard Deviations of Basic Data

A. Japan

(1) Data Set	(2) H	(3) S	(4) ΔH	(5) ΔS
(1)Aggregate	57.3	52.5	.53	.65
	(12.7)	(14.6)	(.39)	(.62)
(2)Manufacturing	26.8	48.6	.35	.85
	(8.6)	(18.1)	(.59)	(1.35)
(3) Fin. gds.	10.6		.15	
	(3.5)		(.30)	
(4) WIP	8.9		.12	
	(2.8)		(.22)	
(5) Raw mat.	7.4		.08	
	(2.4)		(.24)	
(6)Wholesale	10.9	57.3	.19	1.05
	(4.0)	(22.2)	(.37)	(2.39)

B. United States

(1) Data Set	(2) H	(3) S	(4) ΔH	(5) ΔS
(1)Aggregate	700.2	737.6	4.72	4.86
	(108.4)	(114.3)	(5.91)	(6.18)
(2)Manufacturing	289.1	163.4	1.23	.85
	(35.2)	(19.8)	(2.83)	(4.48)
(3) Fin. gds.	92.3		.40	
	(10.8)		(1.09)	
(4) WIP	98.8		.50	
	(12.6)		(1.44)	
(5) Raw mat.	98.1		.33	
	(13.5)		(1.59)	
(6)Wholesale	112.1	85.2	1.10	.90
	(27.1)	(21.0)	(1.41)	(2.51)

Notes:
1. The sample period is 1967:1 to 1987:4. Units in panel A are trillions of 1980 yen, in panel B are billions of 1982 dollars.
2. Each row gives the mean (standard deviation) of the variable listed in the header to the column.

Table III

Contribution of Inventories to Peak to Trough Declines in GNP, 1967-1987

A. Japan

(1) Cycle	(2) Peak in in ΔQ	(3) Trough in ΔQ	(4) Change in ΔQ	(5) Change in $\Delta^2 H$	(6) 100*(5)/(4)
70:3-71:4	71:1	71:4	-979	-14	1.4
73:3-75:1	74:3	75:1	-1046	-138	13.2
77:1-77:4	77:1	77:3	-885	-79	8.9
80:1-83:1	80:1	80:2	-903	221	-25.5
85:2-86:4	85:2	86:1	-1389	-80	5.6

B. United States

(1) Cycle	(2) Peak in in Q	(3) Trough in Q	(4) Change in Q	(5) Change in ΔH	(6) 100*(5)/(4)
69:3-70:4	70:3	70:4	-5.5	-3.8	68.6
73:4-75:1	73:4	75:1	-30.0	-19.5	65.0
80:1-80:3	80:1	80:2	-19.1	-.5	2.3
81:3-82:4	81:3	82:3	-27.5	-11.2	40.9

Note:
1. Units in columns (4) and (5) are billions of 1980 yen (panel A) and billions of 1982 dollars (panel B).

Table IV

Relative Variability of Production and Sales

A. Japan

(1) Data Set	(2) $\frac{var(\Delta Q)}{var(\Delta S)}$	(3) $E(S\Delta H)$	(4) $\frac{E(S\Delta H)}{var(\Delta Q)}$	(5) $E(Q^2-S^2)$	(6) $\frac{E(Q^2-S^2)}{var(\Delta Q)}$
(1) Agg.	.88	$-.3x10^3$	-.13	$52x10^3$	.23
(2) Manu.	1.09	$186.6x10^3$	.09	$572x10^3$	.29
(3) Whole.	1.16	$637.2x10^3$	.10	$1413x10^3$	.21

B. United States

(1) Data Set	(2) $\frac{var(\Delta Q)}{var(\Delta S)}$	(3) $E(S\Delta H)$	(4) $\frac{E(S\Delta H)}{var(\Delta Q)}$	(5) $E(Q^2-S^2)$	(6) $\frac{E(Q^2-S^2)}{var(\Delta Q)}$
(1) Agg.	1.52	68.6	1.17	172.0	2.93
(2) Manu.	1.39	11.1	.40	25.3	.91
(3) Whole.	2.00	4.8	.38	11.5	.92

Notes:
1. Sample period is 1967:1 to 1987:4.
2. Units in columns (3) and (5) are billions of 1980 yen, squared (panel A) or billions of 1982 dollars, squared (panel B).
3. Moments were calculated around a constant and a dummy variable that was unity beginning in 1973:4.

Table V

Augmented Dickey-Fuller Tests for Cointegration between H_t and S_t

A. Japan

(1) Data Set	(2) Residual from Regression of H_t on S_t	(3) Residual from Regression of H_t on S_t
(1)Aggregate	-1.32	-.89
(2)Manufacturing	-3.58	-3.21
(3)Wholesale	-1.68	-1.41

B. United States

(1) Data Set	(2) Residual from Regression of H_t on S_t	(3) Residual from Regression of H_t on S_t
(1)Aggregate	-2.29	-2.09
(2)Manufacturing	-2.49	-2.62
(3)Wholesale	-3.27	-3.32

Note:
1. The figures in columns (2) and (3) are the t-statistics for testing whether the coefficient on the lagged residual is one, in a regression of the residual on its own lag and four lagged differences. Critical values, from Engle and Granger (1987): -2.91 (10 percent), -3.17 (5 percent) -3.73 (one percent).

Table VI

Inventory Sales Ratios

A. Japan

(1) Data Set	(2) Mean	(3) Minimum [Quarter]	(4) Maximum [Quarter]	(5) Growth Rate (std. error)
(1)Aggregate	1.108	.935 [87:4]	1.275 [74:2]	-.028 (.017)
(2)Manufacturing	.563	.445 [87:4]	.739 [75:1]	-.029 (.042)
(3) Fin. gds.	.221	.181 [73:4]	.296 [75:1]	-.022 (.048)
(4) WIP	.188	.150 [87:4]	.238 [75:1]	-.026 (.048)
(5) Raw mat.	.155	.110 [87:4]	.205 [75:1]	-.043 (.055)
(6)Wholesale	.191	.165 [67:1]	.226 [74:3]	.008 (.028)

B. United States

(1) Data Set	(2) Mean	(3) Minimum [Quarter]	(4) Maximum [Quarter]	(5) Growth Rate (std. error)
(1)Aggregate	.949	.897 [67:2]	1.034 [74:4]	.004 (.012)
(2)Manufacturing	1.773	1.569 [73:1]	2.010 [82:4]	-.007 (.036)
(3) Fin. gds.	.567	.495 [73:4]	.660 [75:1]	-.007 (.036)
(4) WIP	.606	.537 [73:1]	.693 [81:4]	-.001 (.034)
(5) Raw mat.	.600	.513 [87:4]	.747 [75:1]	.003 (.033)
(6)Wholesale	1.317	1.170 [74:2]	1.449 [82:4]	-.004 (.021)

Note:
1. Column (5) presents the coefficient and autocorrelation consistent standard error in the regression of the log difference of the inventory/sales ratio on a constant, multiplied by a factor of 100. The sample period is 1967:2-1987:4.