Economics Letters 13 (1983) 337–341
North-Holland

A NOTE ON THE ECONOMETRIC USE OF CONSTANT DOLLAR INVENTORY SERIES

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Received 11 May 1983

One dollar of finished goods inventories does not represent the same amount of physical goods as one dollar of sales, when Department of Commerce constant dollar series are used. This can cause seriously biased regression estimates.

Economic models of production, sales and finished goods inventories are usually formulated in terms of physical units, with costs and revenues assumed to be functions of the number of physical units produced or sold [e.g., Belsley (1969), Blinder (1982), Eichenbaum (1982)]. In empirical estimation of these models, it is assumed that in the data one dollar of finished goods inventories represents the same amount of goods as one dollar of sales. Unfortunately, this is not the case when the standard macroeconomic data sources are used, Department of Commerce constant dollar inventory series on the one hand and constant dollar shipments (calculated by deflating Department of Commerce nominal shipments by the appropriate wholesale price index) on the other. The problem is that the inventory figures are evaluated at what accountants call 'cost', while the sales figures are evaluated at what accountants call 'market'. [1]

* I thank S. Fischer, L. Summers, and, especially, Mr. J. Hinrichs for helpful comments and suggestions, and the Sloan Foundation for financial support.

[1] Foss et al. (n.d., pp. 10,48) and the IRS (1981, p. 106) state that manufacturing inventories are generally evaluated by the firm at cost or the lower of cost or market. For finished goods inventories this in effect means inventories are evaluated at cost. That Department of Commerce constant dollar inventory series still evaluate inventories at cost is implicit in the discussion of how it deflates inventories in Foss et al. (n.d., chs. 5

Table 1 [a]

	Physical units	Current dollars	Constant (period one) dollars
H_0	100	90	100
Q_1			
PI_1		100	
UC_1		1.0	
P_1		2.0	
S_1	90	180	180
H_1	110	109	110
CGS_1		81	
Q_2	100		
PI_2		110	
UC_2		1.1	
P_2		2.1	
S_2	120	252	240
H_2	90	99	90
CGS_2		120	

[a] Q = production, PI = purchases of inventoriable goods, labor and overhead, UC = unit cost = PI/Q, P = market price, S = sales, H = inventories, CGS = cost of goods sold = $PI - \Delta H$.

A simple example will illustrate the problem. In the first column of table 1 is a two period sequence of production of physical units Q_t, sales S_t and end of period inventories H_t; the variables of course obey the identity $Q_t = S_t + H_t - H_{t-1}$. Sales in current dollars in the second column of the table is calculated simply by multiplying units sold by the market price P. The current dollar (book) value of inventories in this column is derived as follows. First, the firm's purchases of inventoriable goods, labor and overhead are summed to get the variable called PI in the table. Exactly what expenditures constitute PI depends on the firm's accounting policy [2] and is not important in the present context; but it is

and 13), Herman et al. (1976, pp. 20–22), Hinrichs and Eckman (1981) and was stated explicitly by Mr. John Hinrichs of the Bureau of Economic Analysis in telephone conversations with me.

[2] At a minimum PI must include all variable costs such as wages of production workers, purchases of materials used in production, expenditures on heat and light and rent; taxes and the amortized value of fixed costs such as depreciation may be included at the option of the firm, provided IRS regulations are met [Foss et al. (n.d., chs. 2 and 10)].

worth noting that for a firm with positive accounting profits, PI in general is less than current dollar sales. PI may be divided by the total number of units produced to get a unit cost UC. Book value of inventories equals the sum of the unit costs of all goods in inventory. If the unit cost of all 100 units of period zero inventories is \$0.90, and the firm uses FIFO accounting, then the book value of inventories is as indicated in column 2 of the table [e.g., $\$109 = (10 \times \$0.90) + (100 \times \$1)$]. Cost of goods sold CGS is defined as $PI - H$.

As may be seen, the ratio of nominal sales to book value of inventories overstates the ratio of units sold to units in inventory. This is because market prices will in general be above unit cost when the firm is making an accounting profit. And this overstatement remains even if sales and inventory figures are deflated to period one dollars, as may be seen in column 3 of the table. The Department of Commerce computes constant dollar inventory series in effect by calculating what the firm would have evaluated its inventories at if there were no inflation in the prices paid for purchases of inventoriable goods, labor and overhead. Since market price will in general be higher than unit cost, an overstatement remains.

It is obvious that if a dollar of inventories is to represent the same amount of goods as a dollar of sales, the constant dollar inventory figures should be multiplied in all periods by the base period ratio of market price to unit cost (equivalently, the constant dollar sales figure should be divided by this ratio). This ratio may be approximated from an individual firm's annual report as the ratio of S/CGS. (In the example, $S_1/CGS_1 = 2.2$ and thus overstates the correct conversion factor of 2.0. The calculated figure is off because the firm uses book value and not constant dollar inventories in its computation of CGS. The example is misleading in that in real data from manufacturing the bias this induces is likely to be very small. [3]) In aggregate data this same ratio may be computed from the Internal Revenue Service data on revenues and expenses which is available annually at the two digit SIC code level in its publication *Statistics of Income – Corporate Income Tax Returns*. As suggested in Foss et al. (n.d., p. 47n) the ratio of (business receipts)/(cost of sales and operations + rent + repairs + depreciation + taxes) ap-

[3] This is because for manufacturing firms the mean absolute value of $H_t - H_{t-1}$ is very small compared to sales or production [see Feldstein and Auerbach (1976)]. Thus the bias from using the book value of $H_t - H_{t-1}$ is likely to be small.

Table 2
Estimates of ratio of shipments/cost of goods sold (SIC codes in parentheses). [a]

(20) Food	1.1973	(24) Lumber	1.2243
(21) Tobacco	1.3997	(25) Furniture	1.2899
(22) Textiles	1.1779	(32) Stone	1.2842
(23) Apparel	1.2407	(33) Primary Metals	1.1632
(26) Paper	1.2548	(34) Fabr. Metals	1.2636
(27) Printing	1.4149	(35) Machinery	1.3646
(28) Chemicals	1.4064	(36) Electrical	1.3218
(29) Petroleum	1.2081	(37) Motor Vehicles	1.2057
(30) Rubber	1.3079	(37) Transportation	1.1819
(31) Leather	1.2325	(38) Instruments	1.4823
		(39) Other	1.3615
All non-durables	1.2582	All durables	1.2629
	All manufacturing	1.2605	

[a] *Source*: Calculated as described in the text from Table 2 in IRS (1976).

proximates the ratio of (shipments)/(cost of goods sold). [4] Table 2 contains these ratios for aggregate manufacturing at the two digit SIC code level for 1972 (1972 was chosen because it is the base year for the latest Department of Commerce constant dollar inventory series). As may be seen, it is substantial, implying that in general a dollar's worth of finished goods inventories represents about 25 percent more physical goods than a dollar's worth of sales.

We close by noting the effect on regression estimates in linear models of adjusting the constant dollar figures. Suppose we are studying aggregate manufacturing finished goods inventories with a regression equation that has inventories on the left-hand side and lagged inventories and lagged and current sales on the right-hand side. The coefficient estimates on the sales variables that result when these are divided by the 1.2605 ratio from table 2 will be 1.2605 times as large as the ones that result if sales are not properly adjusted. By not adjusting, then, we would underestimate how responsive the level of inventories is to sales by 26 percent. This suggests, for example, that inventories are not quite as implausibly unresponsive to sales as some economists [Carlson and Wehrs (1974),

[4] Foss et al. presumably suggest adding rent and repairs to compensate for direct costs not accounted for in the IRS figure for cost of sales and operations [see IRS (1976, p. 159)], depreciation and taxes to account for 'full cost absorption' [Foss et al. (n.d., ch. 10)]. I thank John Hinrichs for suggesting I use the IRS Statistics to calculate the desired ratio.

Feldstein and Auerbach (1976)] have claimed, since their arguments have rested on comparison of the values plausibly predicted by their models with estimates produced by precisely this regression.

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