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Chapter Title: Measuring Inventory Change in the National Accounts

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4. MEASURING INVENTORY CHANGE IN THE NATIONAL ACCOUNTS

Measurement of changes in business inventories is one of the most critical tasks in the construction of the national income and product accounts. The change in business inventories enters the accounts directly on the product side; on the income side the same inventory change in principle lies behind the calculation of business profits in those industries and kinds of businesses in which inventory is a determinant of income. The cyclical path of the economy cannot be measured accurately unless the inventory change component or inventory investment is measured accurately because inventory investment is very volatile and accounts for much of the variation in GNP over short periods of time.

The chapter begins with a discussion of some basic concepts in national or economic accounting. This is followed by a description of BEA's transformation of Census data on inventories measured in book values reported by business firms into the change in business inventories in the GNP.

SOME ACCOUNTING CONCEPTS

Economic Accounting

National or economic accounting concerns the definition and measurement of production, its sale to final users such as consumers and investors, and the flows of incomes and other proceeds (indirect taxes and depreciation) included in production. (For simplicity the treatment of business transfers and subsidies less current surplus of Government enterprises in the U.S. national accounts is not included in this discussion.)

A comprehensive national income accounting system involves more than systematically recording and presenting results of production activities. It also concerns income flows by sectors, transfers of incomes among sectors, uses of income and saving, sources of investment and saving, and international flows of goods, services, incomes, transfers, loans and investments. This chapter, however, relates only to the production account and its components.

The production account for a closed economy may be presented as follows:

consumption + investment = labor income + property income + indirect taxes + depreciation

To disaggregate this identity further, introduce foreign trade, and modify terminology slightly, it is more practical to use a T-account presentation.

Production

Compensation of employees	Consumption Household Government
Enterprise profits and net interest paid	Investment Fixed investment (gross) Change in business inventory
Indirect business taxes	
Depreciation of fixed capital	Exports Minus imports
Total	Total

This T-account presentation follows the form of the equation that preceded it. The right or expenditure side of the account can also be written in the following way:

Final sales to:
- Households
- Governments
- Investors
- Foreigners (net of imports)

Change in business inventory

What is emphasized in the latter arrangement is that production is defined as the sum of final sales and the change in inventories held by business firms. Final sales are those made to consumers, governments, business investors and foreigners. Final sales are substantially less than aggregate sales. Sales accumulated for all firms in the economy will involve considerable double counting. Aside from capital goods, which are used up over a long period of time, sales of goods and services needed for production or resale by one business to another are considered intermediate and must be netted out. Thus, production can also be defined as aggregate sales less intermediate sales plus the change in business inventories.[1]

To illustrate, suppose there are two firms in a country, a manufacturer (M) and a retailer (R). In a given time period M

[1] In an effort to simplify the subject we avoid more complex concepts of production such as net national product (production as defined in the text less depreciation), gross product at factor cost (production as defined above less indirect business taxes) and national income (the sum of payments to factors of production, that is, compensation of labor and property income).

produces 100 units of goods, which are sold at 100, and has labor costs of 80 but no other costs. There are no taxes, no depreciation, and no material costs. In the same time period, R purchases the entire output of M and has no other costs. R sells half of the goods it purchased at 60 to consumers and retains half in inventory. A national production account would appear as follows:

Production–Period t

Compensation of labor	80	Consumption	60
Profits–			
Of M	20	Change in business inventory of R	50
Of R	10		
Total	110	Total	110

Note that aggregate sales of M and R are 160 but that production consists only of final sales (in this case, sales by R to consumers) plus the change in inventory.

Suppose that in the next time period (t + 1), M again produces 100 units, which it sells to R at a higher price of 1.50 each, that M's sales in aggregate are 150, and that its only expense is wages of 120. R sells 110 units to consumers, depleting its stock by 10 units and ending with a stock of 40 units. It charges 2 for each unit sold and has no other expenses.

Production–Period t + 1

Compensation of labor	120	Consumption	220
Profits –			
Of M	30	Change in business inventory of R	−15
Of R	55		
Total	205	Total	205

The transactions of M are straightforward and require no comment, but those of R merit some attention. R's unit cost of the goods in period t + 1 was 1.50, and since inventory was depleted by 10 units, the change in inventory was entered as −15 (10 × 1.50). Similarly, R's profit was calculated upon the basis of the unit costs of the period t + 1 (110 × [2.0 − 1.5] = 55).

The above T-account presentations illustrate the following concepts:

1. Economic production (for a nation, an industry, or a firm) is the value added to the materials and services it purchases from others (nations, industries, or firms) during the accounting time period and the value added to materials produced in and available from a prior time period. This is, of course, a greatly simplified definition, but it is sufficient for this discussion.
2. Change in business inventories (CBI) is the increase or decrease in the physical quantity of goods in stock in terms of the prices at the time of each increase or each decrease in stock. In the first time period, inventory increased by 50 units and the price of each unit was 1. In the second period, inventory was depleted by 10 units and the price or cost of each unit was 1.50 in t + 1 so that −15 was entered in the accounts.

Relationship of Business Accounting to Economic Accounting

Suppose the transactions shown above for the retail firm (R) are presented in a business accounting financial statement. Assuming the firm started with contributed capital of 100 and profits are retained, and using the FIFO accounting convention described in chapter 2, the financial results would be as follows:

Item	Period	
	t	t + 1
Sales	60	220
Cost of goods sold:		
Beginning inventory	0	50
Plus purchases	100	150
Less ending inventory	50	60
Total	50	140
Profit	10	80

Balance Sheet of R

Item	Period		
	t − 1	t	t + 1
Assets			
Cash	100	60	130
Inventory	0	50	60
Total	100	110	190
Net worth			
Contributed capital	100	100	100
Retained profit	0	10	90
Total	100	110	190

In period t + 1, profit as calculated by the business accountant is 80 but as calculated by the economic accountant is only 55. Similarly, the inventory change is +10 (60 − 50) in the business accounting example, whereas it is −15 in economic accounting. These differences arise because the definitions of inventory and profits in the two accounting structures differ. In economic accounting, inventory withdrawals (and therefore the related profits concept) are based upon unit prices or costs at the time of withdrawal. As shown in chapter 2, there is no one way in which such calculations are made in business accounting. Businesses have a range of options that may be used. The example illustrates one of the commonest.

The production account for period t + 1 shown earlier could take a somewhat different form.

Production–Period t + 1

Compensation of labor		120
Profit		85
Book profits:		
Of M	30	
Of R	80	
Inventory valuation adjustment	−25	
Total		205
Consumption		220
Change in business inventory (CBI)		−15
Book value change	10	
Inventory valuation adjustment	−25	
Total		205

This presentation shows both economic accounting values and business accounting values. The two are reconciled by an inventory valuation adjustment (IVA), which is applied to figures reported by business firms on changes in book values of inventories and book profits to obtain desired economic accounting concepts and measurements.

In practice, under economic accounting the sign of the CBI will be positive when physical stocks accumulate and negative when they decline. The IVA will have a negative sign when prices rise because the change in inventories as recorded by business firms permits inventory holding gains to enter the change calculated as the difference in the book value of inventories between two balance sheet dates. The IVA will have a positive sign when prices decline. The size of the IVA will vary depending on the accounting method employed by the firm. Given the same set of prices and physical quantities, use of FIFO by business firms will yield one IVA while use of average cost will yield another.

Continuous Flow v. Discrete Measurement in Economic Accounting

To introduce this subject consider again the simple two-firm example of a manufacturer (M) and a retailer (R). In period t, one unit is produced and sold by M to R at a price of 10. M has wage costs of 10 and no profit. R makes no sales.

Production–Period t

Compensation	10	CBI (of R)	10

In period t + 1, M produces another unit but wage costs are 12. M sells the unit to R at 12. R sells both units at 20 each to consumers so that personal consumption expenditures (PCE) are 40. Profit is 8 per unit or 16 in total.

Production–Period t + 1

Compensation	12	PCE	40
Profit	16	CBI	−12
Total	28	Total	28

The key point here concerns the change in business inventories. The unit liquidated from stock, although bought last period at 10, is assigned a unit cost of 12 in this period so CBI is −12 (−1 × 12).

Now suppose production (hereafter referred to as GNP) is combined for both periods into an account for one period. That is, suppose t and t + 1 were each half years and now a whole year presentation is needed. Recall that there were three transactions in both periods:

M sold 1 unit to R at 10
M sold 1 unit to R at 12
R sold 2 units to consumers at 20 each or 40

Summing the data for t and t + 1:

Production–Periods t and t + 1 Combined

Compensation	22	PCE	40
Profit	16	CBI	−2
GNP	38	GNP	38

If physical stocks were zero at the start and zero at the close, how is it possible to get a change in business inventories of −2? That is not the result obtained if CBI is viewed as physical stock measured from the opening date to the closing date of the period times the average price of the period. That basis would yield a CBI of zero rather than −2 and a GNP of 40 rather than 38. The distinction is between the continuous flow concept of inventory change (which gives a CBI of −2) and the discrete concept (which yields a result of 0). Under the continuous flow concept, it makes no difference how long or short periods are; the answer is always the same whether periods are treated separately and added or whether the longer period is treated as a whole using the continuous flow concept. Under the continuous flow concept, each addition to or withdrawal from inventory is treated separately and valued at the current price at the time of the addition or withdrawal. By contrast, using discrete measurement gives one answer if two periods are treated separately and added and another if the two are combined and treated as a single period.

All GNP expenditure components are measured using the flow concept and it is the consistent concept for estimating inventory change as well. Consumption, for example, is the sum of individual sales to consumers at the price of each sale. The change in inventory should also be the sum of the individual transactions–that is, increases or decreases in the stock in the prices at the time of each increase or each decrease. In the example cited, taking account of each transaction results in: (+1 × 10) + (+1 × 12) + (−2 × 12) = −2.

It has been argued that the discrete change from one balance sheet date to the next is a more interesting and useful number for analytical purposes. Both methods provide useful analytical data, but the continuous flow concept is the ideal measure for economic accounting of production, a measure which conventional balance sheets do not yield.

CALCULATING INVENTORY CHANGE IN THE GNP

Actual measurements of inventory change involve complex procedures and imperfect data, which only approximate application of desired concepts.

Consider a case where three firms have identical physical stocks but use different inventory valuation methods. Quantities and values could be as follows, as shown in chapter 2:

Firm	Valuation method	End of period 1		End of period 2	
		Units	Book value	Units	Book value
1	FIFO.....	10	100	11	136
2	Average cost.....	10	95	11	127
3	LIFO.....	10	60	11	72
	Total..	30	255	33	335

The three firms report only book values to the Census Bureau, which has typically summed the values as shown. However, for calculating GNP, the change of 80 in the book value of inventories (335-255) is not appropriate. If the cost of the units in inventory is assumed to have averaged 12 throughout period 2, the change in physical inventory units, 3, multiplied by an average price of 12, yields a change in inventories at current prices of 36. For the GNP, the results wanted are: CBI (36); book value change (80); and IVA (−44).

To obtain the exact answer in this example it is necessary to resort to a company-by-company calculation. The opening and closing book value of inventory of the FIFO firm must be processed with price indexes appropriate to its own ending inventory values and the resulting change multiplied by its own average price for period 2. The same applies to the firm on average cost. No adjustments are needed for the LIFO firm in the example; the increase of 12 in the value of its inventory can be used directly in the GNP. However, a LIFO firm may also require an IVA if its stock has declined. The point to be stressed is that precise calculations require a company-by-company approach, but the information available to BEA to make its calculations is highly aggregated and imperfect in many ways. BEA makes adjustments on a highly aggregated basis that ideally should be done in a disaggregated way.

The pages that follow provide a step-by-step review of how BEA uses book value data to arrive at an estimate of the change in business inventories in the national accounts. The aspects of inventory change that underlie the calculation of profits are discussed in chapter 7. In this section a simplified description of BEA's general procedure is provided, which is followed with details of a specific example from the electrical machinery industry (SIC 36). Data sources and data shortcomings are noted, as well as deficiencies in procedures. The calculations described for industry 36 are followed exactly for most other industries; the few industries treated differently generally are apparent from the footnotes at the end of appendix D. A number of recommendations are offered, but it should be observed that numerous improvements based on new information were introduced in the GNP benchmark revision published in January 1976. Furthermore, BEA has extensive plans underway for additional improvements.

The focus below is on estimates of yearend inventories made by BEA in July. Preliminary yearend GNP figures are published about 20 days after the close of each year. For these estimates of yearend inventories, BEA must make informed guesses of changes in book values of inventories during December that must be added to November estimates which are mainly preliminary. One month later BEA revises its initial yearend estimate in the light of new information, most of which is still preliminary. Under BEA's publication schedule this estimate is retained until BEA publishes its July revision.[2] Changes may be made in July of the following 2 years to reflect new and revised source material.

BEA Procedures: Overview

In calculating the change in business inventories in current prices on an annual basis, BEA carries out an elaborate set of calculations. The main steps may be summarized as follows:

1. The book value of inventories is divided into LIFO and nonLIFO portions.
2. The change in LIFO inventories is assumed to be in current prices if the inventory change during the year is positive. If it is negative the change is reflated to current period prices.
3. The nonLIFO portion is deflated by indexes which are estimates of the prices embodied in end-of-year book values. This involves a complex set of calculations, which can be divided into three main parts.
   - Determination of the commodity composition of stocks.
   - Determination of the dating for the prices or costs at which various commodities are included in the inventory.
   - Adjustment of yearend nonLIFO inventories down to market where market is lower than cost.
4. The change in nonLIFO inventories in base period prices is obtained by subtracting deflated book values for end-of-year t from deflated book values for end-of-year t + 1.
5. The inventory change in (4) is reflated to current prices by an average index for the given year.

[2] Beginning in 1977, BEA introduced a third estimate of the quarterly data appearing 75 days after the close of the quarter.

6. The change in all inventories in current prices is obtained by adding the results in (2) to those in (5).
7. The IVA is the difference between the change in business inventories as defined in (6) minus the change in book values.

Industry Disaggregation

Before the January 1976 benchmark revision, BEA carried out its inventory calculations for about 30 industry categories. In the January 1976 revision retail trade was expanded from 2 to 8 and wholesale trade from 2 to 17 kinds of business. At present BEA carries out its calculations for about 50 separate industries or industry groups. These are shown in appendix D.

The greater the disaggregation the better the results on average, as demonstrated in table 4.1, which contains a comparison of changes in retail inventories in nondurable goods stores calculated on two bases. The figures on the left, which are those now being published, reflect disaggregation into four categories: food, apparel, general merchandise and all other nondurables. That is, inventories in each of the four groups were deflated separately. The figures on the right reflect the use of the same deflators, but were applied to a single inventory total for retail nondurables. For most years the figures are close, but pronounced differences in the quarterly data are apparent in the 1973-75 period of very rapid price change. It is interesting to note that on an annual basis there is little difference between the two sets of figures from 1973 to 1975.

Table 4.1. **CHANGE IN BUSINESS INVENTORIES IN RETAIL NONDURABLES UNDER TWO BASES FOR AGGREGATION**

(Billions of 1972 dollars, seasonally adjusted at annual rates)

Year and quarter	With disaggregation[1] (current basis)	With no disaggregation (old basis)
1967	0.8	0.8
1968	.6	.6
1969	1.2	1.2
1970	.9	.9
1971	1.8	2.0
1972	1.2	1.1
1973	1.4	1.4
1974	-1.3	-1.3
1975	-.4	-.2
1976	1.9	2.0
1973:		
1st quarter	1.1	0.5
2nd quarter	.2	-.3
3rd quarter	-.5	-.4
4th quarter	5.0	5.8
1974:		
1st quarter	-1.1	-1.3
2nd quarter	1.0	1.7
3rd quarter	-.7	-1.4
4th quarter	-4.3	-4.1
1975:		
1st quarter	-1.1	-.2
2nd quarter	-1.2	-1.3
3rd quarter	.8	.6
4th quarter	.1	.1

[1]Separate deflation of inventories in food, apparel, general merchandise and all other.

Source: Unpublished data supplied by Bureau of Economic Analysis.

PROCESSING LIFO STOCKS

The measurement of inventory change by firms using LIFO approximates in many ways the concept of inventory change used in the GNP. Consequently, determining LIFO inventories in book value totals has been the first step in the process of estimating inventory change in the GNP. Prior to 1975 there were no surveys that regularly included questions on methods of inventory valuation. However, information from occasional surveys was acceptable as long as few firms changed their methods of valuing inventory and the rate of inflation was not high. Under these circumstances, BEA's measurement problems were relatively straightforward. In a given industry, LIFO inventories were obtained by multiplying end-of-year book values by an estimated LIFO proportion that was assumed to hold for beginning and ending inventories of a given year.

$$L_t = \left(\frac{L}{BV}\right)(BV_t). \qquad (1)$$

where

$\frac{L}{BV}$ = the estimated proportion of LIFO inventories of the total book value of inventories in an industry at the end of a given year t

BV_t = the book value of inventories at the end of t.

LIFO inventory change during a given year is:

$$L_{t+1} - L_t = \left(\frac{L}{BV}\right)(BV_{t+1}) - \left(\frac{L}{BV}\right)(BV_t). \qquad (2)$$

The substantial shifts to use of LIFO in recent years caused many difficulties. For example, on the basis of survey data LIFO proportions for the yearends of 1973, 1974 and 1975 were estimated at 23 percent, 28 percent and 33.5 percent, respectively, in the electrical machinery industry. These are large changes, which yielded two values for ending inventories in 1973 and 1974, as shown in the following table.

BEA assumed that the increases in proportions reflected changes in accounting methods rather than changes in inventories with accounting methods held constant. The change in LIFO stocks for a given year was obtained by applying the same LIFO proportion to both beginning and ending book values. This yielded the following (in billions of dollars):

End of year	Census Book Value	LIFO stocks using LIFO proportion from		
		1973 survey	1974 survey	1975 survey
		(Billions of dollars)		
1973	12.30	2.83	3.44	(X)
1974	14.60	(X)	4.09	4.89
1975	13.30	(X)	(X)	4.46

X Not applicable.

1974 Calculation Using End-of-1974 LIFO Proportion

	Book Value	Value of LIFO Stocks
	(Billions of dollars)	
Beginning	12.3 X .28 =	3.44
Ending	14.6 X .28 =	4.09
Change in LIFO stocks		.65

1975 Calculation Using End-of-1975 LIFO Proportion

	Book Value	Value of LIFO Stocks
	(Billions of dollars)	
Beginning	14.6 X .335 =	4.89
Ending	13.3 X .335 =	4.46
Change in LIFO stocks		−.43

The increase in LIFO inventories during 1974 can be used directly as part of the CBI. However, because LIFO stocks declined in 1975 an additional calculation is required for that year. When LIFO stocks are reduced the depletion is valued at prior period prices according to business accounting principles. That is, the decline in LIFO stocks during 1975 was recorded in 1974 prices or even 1973 prices depending on whether the decline fell short of or exceeded the 1974 addition to stocks. For the electrical machinery industry, the depletion in 1975 was less than the 1974 increase so only 1974 prices had to be used. Hence, BEA restated the decline in inventory from 1974 prices to 1975 prices. (See index values below.)

$$-0.43 \times \frac{150.0}{138.5} = -0.47 .$$

For quarterly estimates and for the first yearend inventory estimates (the GNP figures published in January and February following a given year), BEA uses LIFO proportions that are the same or essentially the same as those in the most recent year for which survey data are available from the Census Bureau. For the July revision, some new preliminary Census data become available according to current schedules. Thus, until the July revision, BEA assumes that LIFO inventories within the electrical machinery industry have the same pattern of movement as nonLIFO inventories. This is a questionable assumption, particularly since firms that employ LIFO tend to manage their inventories very carefully to avoid depletions which increase tax liabilities. What is needed for greater precision is prompt tabulation of the actual behavior of LIFO and nonLIFO inventories within each industry. The Census Bureau is now collecting data of this type.

PROCESSING NONLIFO STOCKS

In adjusting nonLIFO inventory book values to GNP concepts, BEA uses a procedure similar to that of business in its use of the dollar value LIFO method. (See chapter 6.) First, the amount of nonLIFO stock is determined from data already calculated for LIFO processing. For example, in the table below in each of the last two columns two values are shown for end of 1974 inventories for electrical machinery. At the end of 1974, nonLIFO firms had inventories valued at $10.51 billion according to the 1974 survey and $9.71 billion according to the 1975 survey. During 1975 additional firms switched to LIFO. The difference between $10.51 billion and $9.71 billion is an estimate of the value of inventories at the end of 1974 of those firms that shifted to the LIFO method during 1975.

Status	Census Book Value	LIFO Inventory	NonLIFO Inventory
	(Billions of dollars)		
For calculating 1974 change			
End of 1973	12.30	3.44	8.86
End of 1974	14.60	4.09	10.51
For calculating 1975 change			
End of 1974	14.60	4.89	9.71
End of 1975	13.30	4.46	8.84

Determining Commodity Composition

The next operation is to deflate the nonLIFO inventory to base period (1972) prices. This requires information on commodity composition of stocks, age of stocks, and price and cost indexes appropriate to the composition and age.

In table 4.2 the estimated commodity composition of inventories in electrical machinery is shown in the first column, the

relative importance or weight of each item in the second column, and the code of the WPI used for deflation in the final column.

Table 4.2. **COMMODITY COMPOSITION OF INVENTORIES, WEIGHT AND WPI CODE, ELECTRICAL MACHINERY**

Commodity	Weight	WPI Code
Industrial chemicals	.009	06-10
Plastic resins and materials	.027	06-60
Pulp, paper, etc.	.015	09-10
Finished steel products	.063	10-13-02
Nonferrous metals	.170	10-20
Hardware	.005	10-40
Miscellaneous metal products	.049	10-80
Metalworking machinery and equipment	.025	11-30
Electrical machinery and equipment	.432	11-70
Household appliances	.133	12-40
Home electronic equipment	.072	12-50
Total	1.000	

Source: Unpublished data supplied by Bureau of Economic Analysis.

Under present BEA procedures the commodity composition of inventories is still based on data from the 1963 input-output table and the 1967 Censuses of Manufactures, Wholesale Trade, and Retail Trade. But the problem is not merely that these sources may be obsolete for recent years. The commodity composition data have many shortcomings. Most important, perhaps, is that direct measures of the commodity composition of inventories are not available from these censuses or other sources. The commodity composition of materials in inventory is based on the composition of materials consumed in manufacturing. The composition of finished goods inventories held by manufacturers and of all inventories held by wholesalers and retailers reflects the commodity composition of sales as estimated by BEA.

If each of the different commodities in a stock turned over at the same rate, recourse to sales and materials consumption data would give the correct inventory composition, but this is hardly the case. A manufacturer using several different materials as inputs is likely to view each of the materials differently because the factors governing desired stocks, stock-consumption or stock-sales ratios—volatility of price, storage requirements, lags between orders and receipts of goods, perishability and so forth—differ from commodity to commodity.

Department store data compiled by the National Retail Merchants Association illustrate how well a distribution of sales by department can serve as a proxy for a distribution of inventories by department. In table 4.3 are shown numbers of stock turns per year (sales divided by average inventory valued at retail), the percent distribution of sales, and a derived distribution of inventories. Although the sales and inventory distributions are close for most departments, fairly pronounced differences are apparent for adult female apparel, which has the most stock turns, and for furniture, which has the least.

Stage-of-Fabrication Data

In manufacturing, the commodity composition of stocks is not simply a reflection of the distribution of material inputs and sales. The weights shown in table 4.2 are dependent on census data that separate manufacturers' inventories into

Table 4.3. **NUMBER OF STOCK TURNS AND PERCENT DISTRIBUTION OF SALES AND STOCKS, BY DEPARTMENT, 1974**

Department Number	Department	Stock Turns	Percent Distribution	
			Sales	Stocks[1]
1000	Adult female apparel	4.1	21.8	14.5
2000	Adult female accessories, etc.	2.9	12.2	11.5
3000	Adult male apparel	2.5	13.1	14.2
4000	Infants', boys' and girls' apparel, etc.	2.7	10.8	10.9
5000	Personal needs and smallwares	3.0	7.3	6.6
6000	Hobby, recreation and transportation	2.3	8.7	10.3
7000	Home furnishings—furniture	1.9	8.9	12.7
8000	Home furnishings—appliances	2.5	4.5	4.9
9000	Domestics, draperies, etc.	2.0	7.2	9.8
	Budget store		5.5	4.6
	Total		100.0	100.0

[1] Derived from the first two columns.

Source: National Retail Merchants Association, Financial Executives Division, "Merchandising and Operating Results of 1974," New York.

three classes by stage of fabrication: purchased materials, work in process, and finished goods. The weaknesses in these stage-of-fabrication data were outlined in chapter 3.

According to the 1967 Census of Manufactures, inventories held by plants in the electrical machinery industry showed the following percent distribution by stage of fabrication:

Purchased materials	33.8
Work in process	34.4
Finished goods	31.8
Total	100.0

The usual BEA procedure is to match as closely as possible inventories of purchased materials with wholesale price indexes for materials, and inventories of finished goods with price indexes for finished goods. However, the treatment of work in process inventories creates problems. The absence of price indexes for work in process—automobiles without engines or air conditioners without compressors—requires that some form of adjustment be made. According to present BEA procedures half of work-in-process inventories are assigned to purchased materials and half to finished goods. Consequently, applying this procedure to the 1967 figures for electrical machinery given above results in—

Adjusted purchased materials	51.0	(33.8 + 17.2)
Adjusted finished goods	49.0	(31.8 + 17.2)
Total	100.0	

The adjusted proportion of purchased materials in the example is thus governing for the combined weight of the materials price indexes while the adjusted finished goods proportion is the determinant for the weight of the finished goods price indexes.

The entire process as described thus far has several shortcomings. First, the composition weights are determined and fixed for a number of years. Technically, the deflation process requires shifting weights, that is, a Paasche index should be used whenever detailed price indexes are weighted upward to an aggregate deflator. This is the case whether one is deflating consumption, Government purchases or any item. The formula is—

$$\sum_{1}^{n} Q_1P_0 = \frac{\sum_{1}^{n} Q_1P_1}{\left.\dfrac{\sum_{1}^{n} Q_1P_1}{\sum_{1}^{n} Q_1P_0}\right\}\text{Paasche price index}} \qquad (3)$$

Since the objective of deflation is to arrive at ΣQ_1P_0, current quantities at base period prices, it is always necessary to divide an aggregate current dollar value (ΣQ_1P_1) by price indexes with current period weights. That is, the weights of each period should be the quantities of that period as shown in the formula for the Paasche index above.

Second, the procedure relies exclusively on sales price indexes. However, finished goods and work in process in manufacturers' inventories are valued at costs to manufacturers, which may not behave in the same fashion as selling prices of those finished goods as measured in the WPI. In addition, the composition of available wholesale price indexes may not match the commodity composition of inventories, giving rise to needs to force matches. In other cases BEA is able to achieve matching only at relatively high levels of aggregation.

Third, the BEA procedure for determining weights for the prices of purchased materials and finished goods may be unsound. We believe that price indexes of materials are underweighted. If this is true, to the extent that prices of materials and finished goods show different movements, the deflation is in error. The fundamental problem concerns the weights to be assigned to purchased materials in total manufacturing inventories. When inventories are separated by stage of fabrication, from a cost standpoint they should be viewed as follows:

	Cost Composition
Materials	Materials
Work in process	Materials plus some labor and overhead
Finished goods	Materials plus all labor and overhead embodied in finished goods inventories

Consider the following example of a product manufactured in a four stage process:

Production stage	Materials	Labor	Overhead	Total	
				Stage	Cumulative
1	10	3	1	14	14
2	10	3	1	14	28
3		3	1	4	32
4		2	1	3	35
Cost of finished goods	20	11	4	35	35

In this example the materials cost is more than half the finished goods valuation (20 of 35) and, of course, considerably more than half of the work in process. If an even flow is assumed, that is, there is an equal number of units at each of the first three production stages, materials and work in process would be as follows:

Stage	Materials	Work in process
1	10	14
2	20	28
3	20	32
Total of all stages	50	74

Thus, in this hypothetical presentation 68 percent of the work-in-process inventories (50 of 74) is materials.

Recent actual values for all manufacturing can be estimated from Census Bureau and Internal Revenue Service data. According to the 1972 Annual Survey of Manufactures, shipments totaled $756 billion and cost of materials $407 billion–54 percent of the value of shipments. The Census Bureau does not collect data on cost of goods sold, but this can be approximated from IRS data published in *Statistics of Income, Part II.* From this source we estimated the ratio of cost of goods sold to sales to be 79 percent for all manufacturing in 1972.[3] Multiplying this ratio by value of shipments yields an estimate of $600 billion for cost of goods sold; of this, cost of materials, at $407 billion is 68 percent. Although these estimates are not precise, they are sufficiently accurate to indicate that the materials content of finished goods inventory should not be greatly different for all manufacturing. For work in process, the materials content should be higher than 68 percent in the typical manufacturing industry in which materials are introduced at relatively early production stages and are processed by applications of labor and overhead in later stages.

In the four-stage example it was assumed that proportionately more materials enter early stages of the production process than late stages. That is certainly the case in most industries. To illustrate, cold-rolled sheets are produced by first combining iron ore and coke to make pig iron, and then pig iron and scrap are combined to make steel ingots. In later stages the thickness of ingots is reduced by rolling and finishing processes that, on average, require very little in the way of new materials. Of course, although "front loading" of materials may be most common, processes with evenly distributed flows of materials or even "end loading" can also be found in manufacturing and should be taken into account in calculating weights.

As noted above, we believe there has been considerable underweighting of the material content of manufacturers' inventories because BEA assigns only half of work in process to materials. If movements of prices of purchased materials are identical to those of other prices and costs, this underweighting has no great significance. In fact, however, fluctuations in prices of materials have been greater than those in prices of finished goods. To demonstrate this point in a general way, seasonally adjusted percentage changes were calculated over 3-month spans in the WPI and in its finished goods component, which accounts for about one-third of the weight. "Finished goods," as used in the WPI, refers to consumer finished goods and to producer finished goods, or to goods sold to final demand sectors. If the overall WPI shows greater changes than the finished goods component, it must be attributable to prices of crude materials and intermediate products. From 1967 through 1976 (for 40 quarterly changes–from the last month of the preceding quarter to the last month of the given quarter), the mean change without regard to sign was 1.67 percent for the WPI and 1.44 percent for its finished goods component. The difference was greater in the years of pronounced price change, 1973-75. Quarterly comparisons are shown in table 4.4.

Table 4.4. **PERCENT CHANGES IN WPI TOTAL AND FINISHED GOODS OVER 3-MONTH SPANS, SEASONALLY ADJUSTED**

Year and quarter	WPI finished	WPI total
1972:		
1st quarter	0.3	1.0
2nd quarter	1.0	.8
3rd quarter	1.3	1.4
4th quarter	1.0	2.7
1973:		
1st quarter	3.9	5.3
2nd quarter	2.6	4.3
3rd quarter	3.0	2.8
4th quarter	1.7	2.2
1974:		
1st quarter	5.2	6.5
2nd quarter	2.7	2.5
3rd quarter	5.4	7.3
4th quarter	3.7	3.2
1975:		
1st quarter	.5	-.8
2nd quarter	2.7	1.5
3rd quarter	2.0	2.2
4th quarter	1.1	1.2
1976:		
1st quarter	-.1	.3
2nd quarter	1.5	1.6
3rd quarter	.2	.9
4th quarter	1.8	1.7

Source: Derived from Bureau of Labor Statistics, Monthly Labor Review, various issues.

Determining the Age of Inventories

An inventory at any given time consists of goods bought in different periods. If prices are changing and the book value of inventories is to be expressed in terms of prices in some base period, it is necessary to determine when goods were acquired. BEA does this by approximating the physical turnover of inventory.

If inventories at the end of a year were twice average monthly consumption, under FIFO accounting inventories would reflect acquisition prices of the last month and of the next-to-last month of the year. If stocks were three times average monthly consumption, prices of goods in inventory would reflect those of the last three months of the year, and so forth.

The usual BEA procedure for obtaining turnover ratios

[3]The ratio is obtained by adding to cost of sales and operations (which are mainly direct costs), all repairs, rents, taxes and depreciation. While this calculation may omit some costs applicable to cost of goods sold, it is important to note that not all of the four items mentioned are charged to cost of goods sold. Based on *Statistics of Income-1972, Corporation Income Tax Returns,* table 2.

involves use of data from *Statistics of Income*, in which cost of goods sold are the denominators and closing inventories are the numerators. This procedure for calculating turnover ratios is beset with many difficulties. For instance, the numerator of the calculation–the book value of inventory–to the extent it comprises inventories valued by the LIFO method, is clearly too low because it may include stocks valued at prices of many years ago. Moreover, it is not measured in the same way as cost of goods sold, which under LIFO reflects valuations in current period prices. Even for nonLIFO firms, the calculation at best is a rough estimate of what ought to be measured with physical data or with deflated values.

IRS editing procedures have a special effect on data for the cost of goods sold for manufacturing and other industries. When IRS processes tax returns, the Statistics Division removes from cost of goods sold several identifiable items, such as depreciation, amortization and rent. These items are tallied separately. For manufacturing firms, some of these costs properly are included in the value of inventories and should be retained in cost of goods sold to preserve comparability between numerator and denominator. In summary, the numerator is too small because of the inclusion of LIFO values and the denominator tends to be too small because some costs that should be included have been removed. Perhaps these factors largely offset each other, but whether they do is unknown.

Prior to the 1976 GNP revision, turnover ratios derived from the *Statistics of Income* data were lengthened by approximately 50 percent because of known deficiencies in the procedure which have the effect of understating the average age of goods in inventory. Thus, if stocks were four times monthly sales, instead of using prices for December, November, October and September, the time period would be extended back by more than 2 months to include August and July. The lengthening by 50 percent (a rough judgmental allowance) reflected the following considerations:

(a) For firms using methods other than FIFO or LIFO–such as average cost–some lengthening of turnover, as compared to turnover with FIFO, is required.

(b) An extension is required to allow for the lapse of time between purchase and delivery. Clearly problems arise if the price indexes used for deflation do not reflect delivered prices.

(c) Use of a single turnover for all commodities overweights commodities with short turnover periods.

For the January 1976 GNP revision, availability of newly collected information on methods of inventory valuation, and more refined procedures for estimating weights for deflation to base period prices, resulted in an extension of weights backward in time (that is, lags of the weights were lengthened). Further study of the problem suggests that backward lagging should be even longer than indicated by procedures introduced for the 1976 revision.

The inventory turnover period for electrical machinery, calculated from IRS data for 1967, was 3.46 months; this figure was increased to 5 months. Thus, each month from August through December was given a weight of 20 percent, as shown on the bottom line of the following table. The new procedures used for the January 1976 revision yielded the set of monthly weights for prices shown on the top line.

Status	Dec.	Nov.	Oct.	Sept.	Aug.	July	June
January 1976 revision .	0.18	0.18	0.18	0.17	0.17	0.07	0.05
Preceding.	.20	.20	.20	.20	.20	0	0

The end-of-year deflators for industry 36 are obtained by multiplying the WPI for June through December for each of the 11 commodity groups in the composition by the turnover period weights shown on the top line. The 11 items are then combined into one index value using the commodity composition weights. This procedure yields a deflator of 118.3 for December 1973 inventory, 146.4 for December 1974, and 150.7 for December 1975.

Adjusting to Market Values

Under its procedures BEA attempts to replicate at an aggregated industry level what individual firms do in valuing their own inventories. For most nonLIFO firms, a standard accounting procedure at the end of each year is to value inventory at cost (FIFO, for example) and also at market, and to accept the lower of the two as the value of the ending inventory. (See chapter 2.) BEA has an equivalent step in its processing of nonLIFO inventory for the end of year.

Until the recent benchmark revision, BEA assumed that all nonLIFO firms in each industry used lower of cost or market as the primary option in valuing yearend stocks. That some nonLIFO firms might always use cost and others might always use market as the basis for valuation was not embodied in the procedure. With the January 1976 revision new data on methods of inventory valuation became available for the first time so that it was no longer necessary to make estimates based solely on assumptions. For the electrical machinery industry it was found that no firms use market always–which is a method adaptable to only a few industries–and that only a small proportion of stocks was valued at cost only. The data for nonLIFO firms were as follows:

Always at cost	4.9
Always at market	0
Lower of cost of market	95.1
Total	100.0

To reflect the lower values used by firms that mark down their inventories to market, it is necessary to calculate market price indexes. Since BLS price quotations refer approximately to mid-month and since yearend market values are desired, BEA averages December and January indexes for each of the 11 components of the stock. They are then weighted into an index for the entire industry using the composition weights shown above.

Results obtained by BEA for 1973-75 in electrical machinery are shown below.

End of year	Index of cost	Index of market
1973	118.3	122.4
1974	146.4	149.1
1975	150.7	152.0

Because the cost indexes were always below the market indexes, the former were used. Of course, this calculation rarely yields market indexes that are lower than cost indexes. If market were lower than cost, the cost index would still receive a weight of about 5 percent because cost is always used by approximately that percentage of nonLIFO companies in electrical machinery.

When comparing cost with market values, a step in the BEA procedure, errors from aggregation could be serious. For example, if copper prices decline sharply at yearend, firms holding an inventory of copper will often replace cost prices with December 31 market prices in valuing their inventory. BEA makes one calculation for the whole industry group using very broad price indexes. Copper is merely one component of WPI code 10-20. The BEA procedure gives different results from what would be obtained by a disaggregated item-by-item calculation, company by company.

BEA should benefit from recent innovations made for Census Bureau surveys. In a survey of methods used for valuing end-of-1975 inventories, the Census Bureau asked respondents to separate inventories valued at market because market was lower than cost from those valued at market because market is always used. For the end of 1976, information on use of the following valuation methods was requested from manufacturing firms:

Cost methods

- FIFO
- Average cost
- Standard
- Specific or actual
- Other

Market actually used

- Market used because lower than cost
- Market always used

Deflating NonLIFO Stocks

Final price indexes for industry 36 are used to deflate nonLIFO book values to yield inventory values in 1972 prices. Changes from the beginning to the end of years in 1972 prices are then obtained.

Reflating the Change in NonLIFO Stocks

The change in business inventories in the GNP is defined as the change in physical or constant dollar stocks during a period valued at current prices. Before discussing the BEA reflating procedure, it should be noted that the BEA definition in this respect is ambiguous. "Current prices" during a period can take on several meanings in the absence of further specification. Current prices can denote prices at which goods are newly ordered or prices at which goods are actually charged to inventory. Sometimes order prices and delivery prices are identical, but they need not be. The problem is complicated because deliveries may reflect spot prices, contract prices or a combination of the two. The relative importance of spot and contract purchases varies across industries and over time and the business cycle. Also, contracts may vary in vintage; during periods of inflation newer contracts will reflect higher prices than older contracts. It is BEA's intention to reflate in terms of average prices at which goods are charged to inventory, which requires use of delivered prices. Some of these matters are discussed at greater length in chapter 5.

A related problem occurs in estimating constant dollar expenditures for producers' durable equipment (PDE). Suppose a machine is ordered in the first quarter, when production commences. Work on the machine progresses uniformly over three quarters and the machine is delivered to the purchaser during the third quarter. Suppose that price indexes for ordering the machine were 100 in the first quarter, 102 in the second quarter, and 105 in the third quarter when the machine is delivered. The purchaser will pay 100, the price at which the machine was ordered. Is that the price at which the machine should be recorded in third quarter PDE? Should the price be 105, the third quarter's new price, which reflects anticipated costs over the next two or three quarters? Or is the correct price a third alternative—one that reflects costs (including margin) in the third quarter? That is, when speaking of PDE in third quarter prices, is the reference to prices that would prevail if all costs and margins required to produce the machine were based on third quarter experience? This subject is not pursued further here but we suggest that devising

Year	NonLIFO stocks			Change in nonLIFO stocks		
	Inventory book value	Price index	Value in 1972 prices	Inventory book value	Price index	Value in 1972 prices
1973	8.86	118.3	7.49			
1974	10.51	146.4	7.18	9.71	146.4	6.63
1975				8.84	150.7	5.87
Change in 1972 prices			-.31			-.76

concepts for measuring GNP in current prices is a topic worthy of more theoretical analysis.

The reflating indexes for industry 36 were obtained from WPI values averaged for January through December for each of the 11 components. For each component, the average for the year is combined by weights reflecting the composition of inventories to arrive at overall reflating indexes for the year.

Year	Reflating index	Value of inventory change in 1972 prices	NonLIFO inventory in current year prices
1974.....	138.5	-0.31	-0.43
1975.....	150.0	-.76	-1.14

A summary of results for industry 36 is shown in table 4.5.

Implications for constant dollar GNP, that is, CBI in current prices converted to 1972 prices, are shown below:

Year	CBI in current prices	Index (1972 = 100)	CBI in 1972 prices
1974.....	0.22	138.5	0.16
1975.....	-1.61	150.0	-1.07

The above calculations for CBI in current prices can be compared with unpublished BEA detailed computer output which are included in GNP aggregates published by BEA in January 1976.

Year	Calculated		BEA	
	CBI	IVA	CBI	IVA
1974.....	0.22	-2.08	0.24	-2.08
1975.....	-1.61	-.31	-1.62	-.31

The small differences reflect use of rounded values as compared to the less rounded values and indexes used in BEA computer operations.

QUARTERLY CALCULATIONS

The focus of this chapter has been on yearned inventory estimates made by BEA each July. This does not imply that quarterly inventory estimates are free from problems. Difficulties caused by BEA's assumption that LIFO proportions are fixed during the year have already been noted, and there is a lengthy discussion in chapter 8 of problems associated with quarterly reporting by LIFO firms, as well as with monthly reporting by companies that utilize standard costs.

Other issues that might be of some importance are those concerning prices and turnover period weights. Now that BEA has computerized its calculations, it can carry out lengthy detailed deflation and reflation every month with up-to-date prices. As for the use of price indexes where cost indexes are the relevant deflators, obviously the previous discussion on annual deflators applies with even greater force for quarterly deflators. Development of quarterly deflators probably will be difficult and entail considerable study and field work.

Finally, freezing turnover period weights is probably no more valid within a given year than it is from one year to another. Possibly experimental work could be done for a few industries for which monthly inventory data are available for a few material inputs. This is possible for the steel industry, where monthly data exist for iron ore, coal, scrap, and steel products. However, information of this kind for other industries is severely limited.

CONCLUDING REMARKS AND RECOMMENDATIONS

In the past, lack of information was an important constraint on achieving greater precision in BEA's work on turnover, deflation, and related procedures. BEA considered its estimates as necessarily rough, so small attempts at refinement were viewed as contributing little improvement to the accuracy of results. This argument is less valid today. Many data improvements have been made in recent years and many more are in the planning or initial stages of implementation.

One thrust of Government regulation is in the direction of recordkeeping that will be useful for inventory statistics. The Securities and Exchange Commission now requires about

Table 4.5. COMPONENTS OF CHANGE IN BUSINESS INVENTORIES (CBI) IN THE ELECTRICAL MACHINERY INDUSTRY, 1974 AND 1975

(Billions of dollars)

Component	1974			1975		
	Total	LIFO	NonLIFO	Total	LIFO	NonLIFO
CBI.....	0.22	0.65	-0.43	-1.61	-0.47	-1.14
Book value change.....	2.30	0.65	1.65	-1.30	-.43	-.87
IVA.....	-2.08	0	-2.08	-.31	-.04	-.27

Source: Based on unpublished Bureau of Economic Analysis data.

1,000 of the largest corporations to provide auxiliary information on cost of goods sold as well as inventory on a replacement cost basis. Thus, many more firms will be doing virtually all the work required for LIFO accounting and will discover the lower profits that result from use of replacement cost accounting during periods of inflation. Therefore, the accounting and administrative burdens associated with use of LIFO will be borne in any event, and an important reason for retaining a nonLIFO method will no longer apply. This regulatory requirement, plus a continuing shift toward LIFO (although at a lower rate than in the early 1970s), should permit substantial improvements in the quality of data available. Precision in these estimates would require virtually company-by-company calculations, but it is not unreasonable to expect that in the not-too-distant future very large firms could be treated individually in calculations of the IVA and CBI.

Industry Disaggregation

The more disaggregation used in inventory measurement, the greater the likelihood of achieving a better quality result. There has been considerable expansion of disaggregation already made by BEA in the trade sectors–from 2 to 17 kinds of businesses in merchant wholesale and from 2 to 8 in retail trade. Further disaggregation is desirable. At this stage, however, more breakdowns should probably be limited to 3-digit manufacturing industries with large stocks for which the book value estimates are reliable.

Commodity Composition of Inventory

In the 1976 benchmark revision, BEA did not revise its procedures for estimating commodity composition. As can be noted in Appendix D, relatively few categories are used for most industries. Greater commodity detail should be introduced. BEA is planning to institute a substantial disaggregation in manufacturing on the basis of the 1972 census data, the latest input-output information, and more detailed price data in the WPI. In manufacturing, the present degree of commodity disaggregation requires the use of about 100 WPI's; the planned disaggregation will use about 400. An extensive expansion of detailed commodities is also needed for retail and wholesale trade. For example, despite the wide range of nonfood products carried in food stores, BEA uses one WPI code–all food–to deflate the nonLIFO inventory of food stores and to reflate the change. Nonfood inventories surely should be taken into account in this process with their own product composition and price indexes. In addition, it would be desirable to disaggregate the food inventory into several types of goods and to apply unique price indexes to each type. Similar comments are applicable to other kinds of retail businesses and to wholesale trade as well. BEA plans to move in this direction.

The foregoing recommendations are standard approaches to improving inventory measurement. Another approach would be to collect data on inventory composition directly in manufacturing. Various ways in which this might be done have been discussed with a number of firms. We learned that, generally speaking, detailed data are not available at the company level. The desired kind of detailed information frequently exists only in physical terms at the plant level.

Although reliable, detailed firm-level data on inventory composition would improve aggregate composition estimates, this is not of utmost urgency. Further study and testing are needed, and might be conducted along the following lines. When a manufacturer is asked to report units and cost of specific materials consumed, as in the census of manufacturers, a request could be added for an estimate of the normal turnover period or normal stock-consumption ratio of each important material. This would permit approximation of the inventory composition of materials. A similar request with respect to shipments could elicit information on finished goods inventories.

Such a procedure could also be applied for retail and wholesale trade. When a survey of sales by merchandise line is collected by the Census Bureau, a request for an estimate of the normal turnover by commodity could be added. This could be manipulated to derive the composition of stocks at sales valuation. If stocks include products with different markups, a further adjustment might be considered.

In this connection, it should be possible to obtain from large department stores both inventories and sales by major department, if not monthly, at least quarterly.

Prices and Costs

The quality of the price and cost indexes entering the deflation process is crucial, possibly more important than any improvements one may achieve by more sophisticated weighting procedures. A separate chapter (chapter 5) is devoted to the subject of price indexes. Beyond this, BEA should undertake a major revision of methods by which it deflates inventories by stage of fabrication. Deficiencies in BEA procedures have been discussed with BEA staff, during the course of this study and major changes are planned. Even if BEA made no other changes in its procedures, at a minimum it should alter current procedures for weighting materials in inventories. Second, BEA should experiment with use of cost indexes in place of the WPI sellers' price indexes it now uses. To assist in this work, the Census Bureau should conduct a special one-time survey to determine the cost composition of inventories for weighting purposes. (See proposal in chapter 13.) This survey should be taken even given the difficulties involved, because appropriate cost data are not ordinarily published and use of LIFO has complicated the problems. Third, BEA should lengthen further its turnover-period price weights.

Other Recommendations

This does not exhaust all of our recommendations for BEA, since some problems are of such importance they are discussed in separate chapters. See especially chapter 7 on changing methods of inventory valuation, chapter 8 on interim reporting, and chapter 10 on overhead costs.

It also might be noted that in an inflationary environment use of historical cost accounting concepts may lead to distorted views of transactions and balance sheet accounts. An intensive review of this problem currently is being undertaken by the accounting profession. Various techniques are being studied for modifying or supplementing traditional historical cost accounting principles for inflation adjustment of financial reports of individual firms. Furthermore, as Solomon Fabricant has observed, this might require modification of BEA and Census Bureau procedures and statistics to reflect inflation adjustments made by firms.[4] Proper allowance for inflationary impacts is of great importance for true measurement of national income, product, and wealth, and we heartily endorse research aimed at revamping historical cost accounting.

[4] See his "Accounting for Business Income under Inflation: Current Issues and Views in the United States," *Review of Income and Wealth*, Series 24, Number 1 (March 1978), pp. 1-24.