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Changes in Inventories in the National Accounts

Manik Shrestha and Segismundo Fassler

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Prepared by Manik Shrestha and Segismundo Fassler[1]

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Abstract

The views expressed in this Working Paper are those of the author(s) and do not necessarily represent those of the IMF or IMF policy. Working Papers describe research in progress by the author(s) and are published to elicit comments and to further debate.

The principles underlying the recording of changes in inventories are explained in the *System of National Accounts, 1993 (1993 SNA)*, but operational guidelines on their measurement are lacking. This paper elaborates specific statistical techniques and their underlying assumptions for calculating changes in inventories and holding gains when only data on stocks of inventories are available. Several data situations are considered. The authors propose methods for measuring changes in inventories that meet the *1993 SNA* principles. The paper also explores possibilities for implementing the proposed improvements and explains the interpretation of data on changes in inventories.

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I. INTRODUCTION

Changes in inventories pose one of the most difficult measurement problems in the compilation of national accounts and are usually among their weakest components. The measurement of changes in inventories affects national accounts' aggregates on production, incomes, and uses [hence, the estimates of gross domestic product (GDP) by production, income, and expenditure approaches]. A closely related issue is holding gains on inventories, which arise from differences in prices between acquisition and disposal of inventories. Holding gains should be excluded from the measurement of changes in inventories in the national accounts. Even with relatively moderate inflation, holding gains can be significant. While holding gains are an important economic phenomenon, they should be separated from transactions and other changes in the volume of assets.

The principles underlying the recording of changes in inventories are well founded and explained in the *System of National Accounts, 1993 (1993 SNA)*, but operational guidelines on their measurement are lacking. In particular, the *1993 SNA* does not provide an assessment of the various statistical techniques that are used in practice and does not make operational recommendations on appropriate methods for the measurement of changes in inventories and holding gains on inventories. Also, the data on changes in inventories are often misinterpreted. This paper aims to clarify the interpretation of the data on changes in inventories and to provide operational guidelines for their measurement.

Section II of this paper explains the *1993 SNA* principles for the recording and valuation of inventories, the relationship between holding gains and inventories, and their implications for the measurement of GDP. Section III summarizes the national accounts approach to recording changes in inventories and data requirements for measuring them. This section also describes business accounting methods for recording inventories and their implications for the measurement of changes in inventories in the national accounts. Section IV elaborates specific statistical techniques and their underlying assumptions for calculating changes in inventories and holding gains when available data relate to (i) quantities of inventories at the beginning and end of an accounting period, and (ii) book values of opening and closing inventories under various methods of historic cost accounting used by enterprises. Improvements to the measurement of changes in inventories in accordance with the *1993 SNA* principles are presented in Section V. This section also explores possibilities for implementing the proposed improvements. Section VI presents the main conclusions.

II. *1993 SNA* ON CHANGES IN INVENTORIES

A. Definition of Inventories

A lag generally exists between production and sale of outputs and between acquisition and use of products. Products held during such intervals (between production and sale or acquisition and use) are called inventories. Paragraph 10.7 of the *1993 SNA* defines inventories as consisting of "(a) stocks of outputs that are still held by the units that produced them prior to their being further processed, sold, delivered to other units or used in other

ways; and (b) stocks of products acquired from other units that are intended to be used for intermediate consumption or for resale without further processing."

Inventories cover goods and services that are produced assets and are held by producers. All inventories held by government are also included. Products acquired by final users are not classified as inventories even when there is a lag between their acquisition and use (for example, a purchase of a fixed asset which will be put to use at a later date). The expenditures on final uses are recorded at the time when the ownership of goods changes or the delivery of services is completed.

Four types of inventories are distinguished in the *1993 SNA*. These are briefly described below.

Materials and supplies consist of goods held by a producer (an enterprise) with the intention of using them as intermediate inputs into production. The concept of intermediate consumption defines the boundary for the inventory of materials and supplies. They may include small tools when these are treated as intermediate consumption. They do not include stock of newly acquired fixed assets (including small tools when these are classified as fixed assets) and valuables which are held as stores of value. Every enterprise, including non-market producers owned by government units, may be expected to hold some inventories of materials and supplies (in some cases consisting of office supplies only), although they tend to be most significant in the goods producing industries.

Work-in-progress consists of output of goods and services which are in the process of production but are not yet finished to be delivered outside the establishment. Work-in-progress must be recorded for any production process that is not finished at the end of the accounting period. Unfinished production that is treated as gross fixed capital formation should not be classified as inventories of work-in-progress. Uncompleted fixed assets are treated as gross fixed capital formation in the following two cases: (i) when they are being produced on own-account by their eventual users, and (ii) when they are being produced under a contract of sale agreed in advance.

Finished goods are goods produced and held by producers. It should be noted that inventories of finished goods can only be held by the enterprises that produce them. The term "finished" indicates that the producer does not intend to process them any further before supplying the goods to other units.

Goods for resale consist of goods acquired by enterprises – typically wholesalers or retailers – for the purpose of resale without further processing (apart from sorting, packing, etc.).

B. Timing and Valuation of Inventories

The accrual accounting approach followed in the national accounts determines the timing and valuation for the recording of stocks and flows. Stocks in the balance sheets, by definition, refer to specific points in time. Flows are aggregations of transactions or other flows over an

accounting period. Accounting rules on the exact timing for recording flows are needed to distinguish between changes in net worth due to transactions and those due to holding gains or losses. Recording at the time when a good is produced, a service is delivered, ownership of assets is transferred, labor is provided or an input is used, is called recording on an accrual basis. This time of recording also governs the timing for determining the prices for the valuation of flows. The accounting rules on valuation specify the type of prices that should be used for valuation (such as basic, producer or purchaser prices)[2] with the general principle that valuation should be at market prices.

Following the accrual accounting principle, additions to inventories are recorded when products are purchased, produced or otherwise acquired; and withdrawals from inventories are recorded when products are sold, used up as intermediate consumption or otherwise relinquished (*1993 SNA*: 3.104). For balance sheet purposes, the prices prevailing on the date to which the balance sheet relates are used.

The *1993 SNA* rules concerning the valuation of different types of inventories can be summarized as follows.

- Entries and withdrawals of **materials and supplies** are valued at purchasers' prices prevailing at the time the entries and withdrawals are made (*1993 SNA*: 6.151).

- Additions to, and withdrawals from, **work-in-progress** are valued at the basic prices prevailing at those times (*1993 SNA*: 6.75). However, the valuation of work-in-progress poses a special challenge as it is a partially-finished product. Several techniques may be followed to approximate the value of work put in place. Estimates by businesses, such as stage-payments made by the purchaser, can be used if they approximate the value of output produced (*1993 SNA*: 6.74). It should be noted that uncompleted fixed assets, for which a contract of sale has been concluded in advance, are not treated as inventories, but as gross fixed capital formation. Other valuation options discussed in the *1993 SNA* relate to the use of production costs incurred in each period together with the value of the finished product at basic prices, if available, or assumed mark-up for operating surplus/mixed income (*1993 SNA*: 6.77-78). An alternative when the costs of production can not be measured would be to use a "cost profile" based on statistical observations, engineering estimates or expert views. A detailed description of various alternatives for deriving an estimate of work-in-progress in the context of quarterly national accounts is given in Chapter X of the IMF's *Quarterly National Accounts Manual* (Bloem, Dippelsman, and Maehle, 2001).

- **Finished goods** entering or leaving inventories are valued at the basic prices of the goods at the time the entries or withdrawals take place (*1993 SNA*: 6.60, 10.112).

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[2] For discussion on the concept of these prices, see *1993 SNA* paragraphs 6.204 – 6.217.

- **Goods for resale** entering inventories are valued at purchasers' prices, including the cost of transportation other than that provided by the enterprise taking delivery on own-account. Reductions in inventories are valued at the purchasers' prices at which they can be replaced at that time, even if they are sold at a loss. (*1993 SNA*: 10-114-115)

The **value of changes in inventories** in a given accounting period is given by the sum of the values of all additions, less the sum of the values of all withdrawals, and less the values of the recurrent losses of goods held in inventory. Recurrent losses of goods (such as recurrent wastage, accidental damage, etc.) held in inventories are valued in the same way as the withdrawals of goods.

C. Holding Gains and Inventories

Holding gains are defined as the change in value of assets and liabilities of institutional units due to changes in prices over time. Holding gains on inventories is just a particular case of holding gains generated by holding an asset (inventories) whose price changes during the period it is held in inventory. As explained earlier, products are held in inventories because of a lag between the time they are produced/acquired and disposed/used. Generally, prices change over the period products are held in inventories, which gives rise to holding gains. Holding gains can be positive or negative, the latter being holding losses. The issue of holding gains does not arise when products are sold at the time they are produced or when products are used at the time they are acquired.

Holding gains are an important economic phenomenon, which affects net worth of institutional units. They should be recorded separately from transactions and other flows (such as output, other volume changes, etc.). The *1993 SNA* distinguishes three concepts of holding gains, viz., (i) nominal holding gains -- simply referred to in this paper as holding gain, (ii) neutral holding gains, and (iii) real holding gains.

The nominal holding gain on a given quantity of an asset is defined as the value of the benefit accruing to the owner of that asset as a result of a change in its price or, more generally, its monetary value over time (*1993 SNA*: 12.63). Nominal holding gains may accrue on assets held for any length of time during the accounting period and not only on assets that appear both in the opening and closing balance sheets of an institutional unit. A distinction is made between realized and non-realized holding gains. Realized holding gains may occur when an asset existing at the opening balance or acquired during the period of accounts is disposed of during the period. Unrealized holding gains may occur when an asset held at the opening balance sheet or acquired during the period is kept until the closing of the accounting period, thus appearing in the closing balance sheet. Holding gains should be recorded on an accrual basis. Therefore, both realized and unrealized gains should be recorded as they occur.

The neutral and real holding gains are the two factors into which the total (nominal) holding gains can be decomposed. Neutral holding gains are defined as the value of the holding gains that would accrue if the price of the asset changed in the same proportion as the general price level, that is, the value of the holding gain needed to preserve the real value of the asset in

question over time. Real holding gains are defined as the value of the additional purchasing power over the real value of the assets accruing to the asset holder as a result of a change in its relative price with respect to the general prices of goods and services in the economy. Box 1 summarizes these distinctions in an algebraic format.

Box 1. Holding Gains and the Relations Between Their Components

a. The nominal holding gain (G) accruing on a given quantity (q) of some asset between time (0) and (t) is:

$$G = (p_t - p_0) * q$$

Where p_0 and p_t are the prices of the asset at times (0) and (t) respectively.

b. Neutral holding gains (NG) on the same asset are:

$$NG = p_0 q \ (r_t/r_0 - 1)$$

Where r_0 and r_t are the general price indices in period 0 and t respectively.

c. Real holding gains (RG) on the same asset are:

$$RG = G - NG = (p_t/p_0 - r_t/r_0) p_0 q$$

D. GDP and Changes in Inventories

The measurement of changes in inventories and holding gains on inventories has an impact on the level of GDP. These issues are explained below for all three approaches (viz., production, expenditure, and income) to derive GDP estimates.

Production approach

GDP is a concept of value added, which is a measure of the additional value created by the productive activity of resident producer units (*1993 SNA*: 2.172, 6.233). Production is an activity in which an enterprise uses inputs to produce outputs. Holding gains are not part of production because they are derived from changes in prices of products that have already been produced (including work-in-progress) and are being held in inventories. Therefore, to exclude the effects of valuation changes on value added, and hence GDP; output and intermediate consumption must be valued at the prices at the time the production and the use of input take place. Only then, the gross value added, which is the difference between output and intermediate consumption, will be a measure of production.

The issue of holding gains on inventories in the derivation of GDP from the production approach arises when output and/or intermediate consumption are measured using financial

data of enterprises. This is the case when output is measured as sales (and other uses) plus changes in inventories of finished goods/work-in-progress and intermediate consumption is measured as purchases less changes in inventories of materials and supplies. In the case of output, a product entering into inventory is counted as output when it is produced, at which time it will be added to inventory. When subsequently the product is withdrawn and sold, no output should be recorded. Therefore, the value of the sale should be offset by the corresponding negative change in inventories, i.e., the withdrawals of finished goods from inventories should be valued at the prices at which the goods are disposed. Similarly, a product is recorded as intermediate consumption when it is used in the production process rather than at the time it was purchased. Therefore, the value of purchases of materials and supplies used as intermediate consumption should be offset by the corresponding change in inventories of materials and supplies. As a result, the use of materials is valued at the prices current at the time of use, i.e. the prices at the time of withdrawal. The numerical example in Box (2) illustrates the relationship between value added and changes in inventories.

Box 2. Gross Value Added and Changes in Inventories

Inventory of materials	Production		Inventory of finished goods	
Purchases (import): Quantity: 5 units Price per unit: 10	Use of materials: Quantity: 5 units Prices at the time of use: 12	Production: Quantity: 10 units Prices at the time of production: 15	Entries: Quantity: 10 units Prices: 15	Sales to households: Quantity: 8 units Prices: 16

Calculation of gross value added (GVA)

Direct calculation:	Calculation based on sales/purchases and inventories:

Output = Quantity produced * current prices
      10 * 15 = 150
IC   = Quantity used * current prices
      5 * 12 = 60
GVA   = Output – IC
      150 – 60 = 90
(IC = Intermediate consumption)
	Output = Sales + Changes in inventory of finished goods
	      (8*16) + [(10*15) – (8*16)] = 128 + 22 = 150
	IC = Purchases – Changes in inventory of materials
	      (5*10) – [(5*10) – (5*12)] = 50 – (–10) = 60
	GVA = Output – IC
	      150 – 60 = 90

Note: It is assumed that there were no opening inventories. Changes in inventories are measured by the sum of additions less withdrawals.

If withdrawals from inventories are not valued at current prices, gross value added will include holding gains. This can be illustrated using the example in Box (2). Assuming that withdrawals are valued at the prices at the time of entry (in the calculation of output and intermediate consumption using data on changes in inventories) and that prices are rising, the effect will be as follows: (i) output will be overstated (158; instead of 150), (ii) intermediate consumption will be understated (50; instead of 60), and (iii) gross value added will be

overstated (108; instead of 90) as it includes valuation effects on both output and intermediate consumption.

The issue of holding gains on inventories does not arise when output is measured directly by using data on quantity produced and current prices. The same conclusion applies to intermediate consumption when it is calculated directly from the quantity of materials used and their current prices at the time of use.

Expenditure approach

GDP at market prices in the System is defined from the expenditure side as total final uses at purchasers' prices less total imports valued free on board (*1993 SNA*: 6.235). The value of change in inventories is one of the components of final uses. Therefore, its measurement is important in the estimates of GDP by final uses.

As mentioned earlier, GDP is a measure of production. Therefore, the GDP compiled from the expenditure approach should also provide a measure of production. As with all other flows, the final uses are recorded on an accrual basis (at the time the ownership of goods is transferred) and valued at the prices at which transactions take place, i.e., purchasers' prices. The value of a product at the time it is acquired for uses may include holding gains.[3] In order to offset the holding gains that the purchasers' price of a product may include, the withdrawals of that product from inventories must be valued at the prices at the time of withdrawal.

If the measure of changes in inventories does not reflect the actual prices at which withdrawals take place, but historic prices are used to value the withdrawals (as in most business accounts), the resulting estimates of changes in inventories will include holding gains that will be reflected in the value of GDP. The numerical example in Box (3) illustrates the relationship between final uses and holding gains on inventories.

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[3] The other components that may contribute to the difference between the value of a product at the time of production and at the time when it is acquired for uses may include taxes/subsidies on products, and trade and transport margins.

<table>
<tr><td colspan="5">**Box 3. GDP from Expenditure, Changes in Inventories, and Holding Gains on Inventories**</td></tr>
<tr><td>Inventory of materials</td><td colspan="2" align="center">Production</td><td colspan="2" align="center">Inventory of finished goods</td></tr>
<tr>
<td>Purchases (import):
Quantity: 5 units

Price per unit: 10</td>
<td>Use of materials:
Quantity: 5 units

Prices at the time
of use: 12</td>
<td>Production:
Quantity: 10 units

Prices at the time
of production: 15</td>
<td>Entries:
Quantity:
10 units
Prices: 15</td>
<td>Sales to households:
Quantity:
8 units
Prices: 16
{End prices=16}</td>
</tr>
<tr>
<td colspan="3">

GDP by expenditure:

Final consumption = Quantity purchased * prices
                8 * 16 = 128
Changes in inv. = Finished goods + materials
                22 + (–10) = 12
Imports = 50
GDP = 128 + 12 – 50 = 90

(GDP equals GVA in the absence of taxes/subsidies)

</td>
<td colspan="2">

Changes in inventories:
Finished goods =   Additions less withdrawals
                   (10*15) – (8*16) = 22
Materials   =   (5*10) – (5*12) = –10

Holding gains:
Finished goods =   Realized + unrealized
                   [8 * (16–15)] + [2 * (16–15)]
                   8 + 2 = 10
Materials   =   Realized
                   [5 * (12–10)] = 10

</td>
</tr>
<tr><td colspan="5">Note: It is assumed that there were no opening inventories.</td></tr>
</table>

As can be seen from the example in Box (3), changes in inventories can be negative even when the physical change in inventories is zero or positive. For example, the physical change in inventory of materials is zero, but the value of changes in inventories is negative. The prices at the time of use (or sale in other cases) of the materials include holding gains, which are realized gains as these products are used or sold. The uses or sales are recorded at their prices. The realized holding gains included in the purchasers' prices of materials are exactly offset in the changes in inventories by valuating withdrawals at the same prices (the prices at the time of use or sale). The example shows that the value of changes in inventory is (–10), which is equal to the realized holding gains. The changes in inventories, therefore, reflect not only the movement in inventories but also adjustment for difference in valuation between production and use due to holding gains, specifically the realized holding gains. As a result, the sum of total final uses less imports yields GDP exclusive of holding gains, a measure of production.

Total holding gains on inventories include both realized and unrealized gains (see Sub-section C above). The valuation adjustment included in the changes in inventories comprises only realized holding gains on inventories.
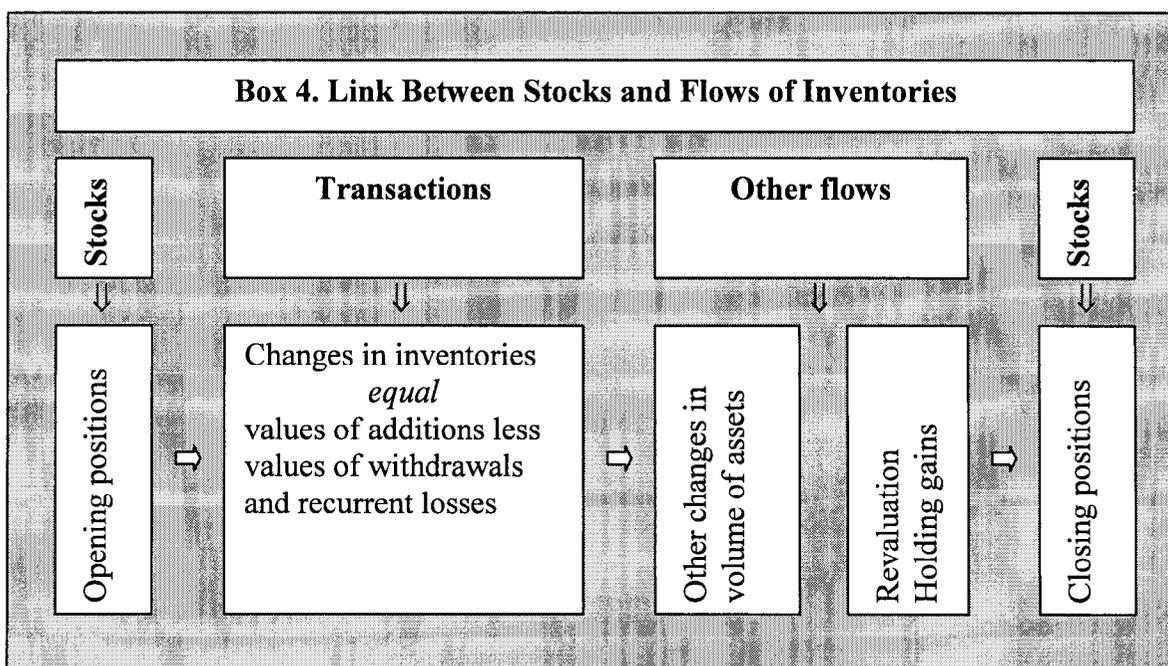
Income approach

The holding gains on inventories affect operating surplus/mixed incomes. When these estimates are derived residually (by deducting compensation of employees and relevant taxes

less subsidies from value added), the output and intermediate consumption should be adjusted, where necessary, for holding gains on inventories (please see the discussion under production approach above). If the estimates of operating surplus are calculated using information from enterprise accounting, they should be adjusted for eliminating holding gains on inventories included in business profits.

E. Recording Flows and Stocks of Inventories in the National Accounts

Inventories, changes in inventories, and the corresponding holding gains are registered across the system of national accounts in the accumulation accounts and balance sheets of institutional sectors. Change in inventories is part of gross capital formation and is registered on the asset side of the capital account. Holding gains on inventories are recorded in the revaluation account, a sub-account of the other changes in assets account.

Accumulation accounts and balance sheets are closely linked. The former fully explain the difference between the opening and closing positions in the balance sheets. Box (4) below shows the links between balance sheet values of inventories, changes in inventories, other changes in volume of assets, and holding gains on inventories.

Box 4. Link Between Stocks and Flows of Inventories			
Stocks	**Transactions**	**Other flows**	**Stocks**
Opening positions	Changes in inventories *equal* values of additions less values of withdrawals and recurrent losses	Other changes in volume of assets / Revaluation Holding gains	Closing positions

Other changes in the volume of assets cover exceptional losses in inventories (such as natural disasters, fire damage, exceptional insect infestation of grains, etc.). Exceptional losses should be distinguished from the recurrent losses of inventories. Recurrent losses are included in withdrawals. Both positive and negative holding gains are recorded on the asset side of the revaluation account.

III. NATIONAL ACCOUNTS AND BUSINESS ACCOUNTING OF INVENTORIES

A. *1993 SNA* Approach and Data Needs

The *1993 SNA* sets out a perpetual inventory method to measure the changes in inventories. This method of calculating changes in inventories requires information on all entries into and withdrawals (including recurrent losses) from inventories valued at the prices the entries and withdrawals are made. The values of withdrawals of inventories from business accounting data, even if they can be obtained, do not fulfill national accounts requirements because enterprises use historic prices. Therefore, for national accounts purposes, data on both quantities and prices of withdrawals are needed. Likewise, data on quantities and prices are needed to derive the balance sheets positions of inventories in the national accounts as stocks of inventories in business accounts are valued at historic prices. Box (5) shows the data requirements to derive estimates of changes in inventories and stocks of inventories fully consistent with the *1993 SNA*.

In practice, the perpetual inventory method is not implemented mainly due to the unavailability of information. Business accounts, the main source of data, have two major shortcomings. First, businesses usually do not keep full details of inventory flows. It should, however, be noted that with advances in accounting software and computer-based inventory systems, businesses may be able to provide more details on inventory movements. Second, business accounting uses varieties of historic cost methods for valuation of inventories, none of which satisfy the national accounting concept of valuation. This suggests that adjustments to business accounting data are needed even when details of inventory movements are available from business accounting records. Specific procedures for making the adjustments to business accounting data on inventories, usually called inventory valuation adjustment (IVA), depend on inventory accounting methods used by enterprises as well as on the details of available information.

B. Enterprise Data and Underlying Accounting Methods

The data on inventories are collected through establishment surveys and from important individual enterprises. They can be data on values of the stocks of inventories and/or quantities of important inventories. Administrative data on stock of inventories (values as well as quantities) held by government agencies responsible for distribution or regulating the supply of important commodities are an additional source of data on inventories.

Enterprise data on inventories that are usually used for deriving changes in inventories for national accounts purposes refer to values of inventories held by enterprises at the beginning and end of an accounting period, which are shown in their balance sheets.[4] Enterprises using

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[4] Data on physical quantities at the beginning and end of period may also be available for some important commodities.

computer-based record keeping systems (which record all entries and withdrawals on a continuous basis) may be able to provide details on inventory movements. However, the values of stocks of inventories and withdrawals (if available) can not be used for national accounts without adjustments for the valuation differences between the national accounts and business accounting. This is because enterprises use historic cost methods for inventory accounting.

There are several versions of historic cost methods. The prices at which the stocks of inventories in the enterprises' balance sheets and the inventory withdrawals (if they can be extracted) are valued depend on the inventory valuation method used by enterprises. It should be noted that all versions of historic cost methods record entries at current prices at the time of transactions, which conforms with the *1993 SNA* concepts. However, withdrawals of inventories under historic cost accounting are valued by enterprises at the prices at the time of acquisition, but not at the prices at the time of withdrawal.

The International Accounting Standards (IAS) allow the use of four types of historic cost methods {International Accounting Standards IAS 2 (revised 1993) paragraphs 19, 21, 23}. The *specific identification* method is recommended for inventories that are not ordinarily interchangeable and for items that are identified for a specific project. However, this method is not practical as products will generally lose their separate identity in the process of production/acquisition and sales/disposals. Because of limited applicability of the *specific identification* method, other methods based on certain assumptions regarding the cost flows associated with inventories are followed. Under cost flow assumptions, the cost flows need not necessarily reflect the physical flow of inventories. The IAS suggests two benchmark cost flow assumptions, namely the *first-in-first-out* (FIFO) method and the *weighted-average cost* method. As an alternative, it also allows the use of the *last-in-first-out* (LIFO) method. There are also other types of historic cost methods that may be used according to bookkeeping practices and tax regulations in different countries. Nevertheless, the FIFO method is likely to be the cost flow assumption most widely applied.

A brief description of the three historic cost flow methods commonly found in business accounting for inventories is presented below.

The FIFO method of inventory valuation assumes that the first items entered into the inventories are withdrawn first. Hence, the withdrawals from inventories are recorded at the prices of acquisition of the oldest item held in inventories. The value of the stock of inventories at any time will reflect the prices of the latest acquisitions.

Enterprises using the weighted-average cost method recalculate the per unit average price based on the quantity and value of inventory available in stock. The weighted-average price may be calculated on a periodic basis or as each additional entry is made. End of period inventories and withdrawals are then valued using these constantly updated weighted-average prices of inventories. The implicit price of the inventories in this method is a weighted average of prices extended back over a long period of time in which the older prices have a decreasing weight. Under inflationary conditions, prices implicit in the value of stock of

inventories reported in the business accounts are lower with this method than with the FIFO method.

With the LIFO method, withdrawals from inventories are valued at the prices of the most recent acquisitions, that is, they are recorded at current market prices or closer to current market prices than under FIFO or weighted-average cost methods. However, the goods remaining in inventories are valued at historic prices of earliest acquisitions. Under inflationary conditions, the prices implicit in the value of stock of inventories according to the LIFO method will be lower than those implicit in the FIFO and weighted-average cost methods.

The differences between the three methods of inventory valuation in business accounts, together with the *1993 SNA* concept of valuation, are illustrated in the example in Box (5).

Box 5. Illustration of Inventory Valuation Concepts in Business and National Accounts

Method	Opening stock			Additions			Average price			Withdrawals			Closing stock		
	q	p	v	q	p	v	q	p	v	q	p	v	q	p	v
FIFO	1	10	10	2	16	32	-	-	-	1	10	10	2	16	32
AVERAGE	1	10	10	2	16	32	3	14	42	1	14	14	2	14	28
LIFO	1	10	10	2	16	32	-	-	-	1	16	16	2	13	26
1993 SNA	1	10	10	2	16	32	-	-	-	1	18	18	2	20	40

Note: The example assumes that one unit of a product was held in inventories at the beginning of the accounting period and that it was acquired on the last day of the previous accounting period. For simplicity, it is also assumed that they were the first transactions in inventories. Hence, the opening stock shows the same per unit price under all three methods (as compared to the per unit prices at the end of the period). The example shows entries of two units at the prices of 16 per unit and withdrawals of one unit during the accounting period. The per unit prices at the time of withdrawal and at the end of the period are assumed to be 18 and 20 respectively. The per unit prices for the opening and closing stocks under the various business accounting for inventories are unit values (values divided by quantities).

For all historic cost methods of inventory valuation, additions are recorded at current prices at the time of acquisition (therefore additions are equal to 32 in all three methods in the example in Box 5). An average price of the stock is calculated for the weighted-average cost method as the new entries into inventories are made (a perpetual inventory system is assumed). As can be seen from the example, withdrawals are valued at different prices under the three methods. Consequently, the values of closing inventories differ between these methods. Statistical collections from business establishments will have these different prices embodied in the values of inventories reported for the beginning and end of an accounting period.

One another important issue related to the business accounting for inventories is that the accounting may be done under either a periodic or a perpetual system. In a periodic inventory system, the inventory quantity is determined periodically, typically at the beginning and end of each accounting period, through a physical count. The quantity so determined is then valued in accordance with the cost flow method followed by enterprises. Businesses may also have full physical stock-takes at less frequent intervals with sampling or indicator methods for more frequent measures. Enterprises following periodic inventory system may be able to provide only inventory levels, but not details on inventory movements.

A perpetual inventory system keeps records of all entries into and withdrawals from inventories, which provides a running total of the inventory level (by quantity and, possibly, cost). Enterprises following this system may be able to provide details on inventory movements (for example, quantities of additions and withdrawals during specific periods). Although the values of withdrawals and stock of inventories would be affected by the historic cost flow methods, the details on inventory movements can provide a suitable basis for deriving changes in inventories for national accounts.

C. Holding Gains on Inventories and Inventory Valuation Adjustments

The concept of holding gains on inventories in the national accounts is not the same as the inventory valuation adjustment (IVA), but these concepts are often confused with each other. Holding gains in the *1993 SNA* arise from changes in prices during the period. The inventory valuation adjustment is a measure of holding gains included in the change in the book values of inventories[5] shown in the balance sheets of enterprises. The changes in book values of inventories in business accounts will include valuation effects arising from the use of historic cost flow methods. Different historic cost flow methods lead to different inventory valuation adjustments as they generate different book values of inventories. When book values of inventories are used in compiling national accounts, valuation effects arising from historic cost flow methods should be removed from inventories and incomes through an inventory valuation adjustment, which depends on the type of historic cost flow methods. The holding gains on inventories and the inventory valuation adjustment for different historic cost flow methods are illustrated in Box (6) using the information from the example in Box (5).

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[5] Book values of inventories refer to the values of stock of inventories in the commercial balance sheets drawn up by enterprises.

	1993 SNA	FIFO	AVERAGE	LIFO
Box 6. Holding Gains on Inventories and Inventory Valuation Adjustments				
Closing stock	40	32	28	26
Opening stock	10	10	10	10
Changes in balance sheets	30	22	18	16
Changes in inventories	14 = 32–18			
Holding gains	16 = 30–14			
IVA		8 = 22–14	4 = 18–14	2 = 16–14

Note: Given the inventory movements and their prices, the value of changes in inventories and holding gains will respectively be 14 (additions less withdrawals) and 16 (changes in balance sheet values less changes in inventories) according to the *1993 SNA*. The IVA measures the holding gains included in the book value changes. Given the value of changes in inventories, the FIFO method in this example will include holding gains of 8 in the book value changes of 22, the weighted average method – holding gains of 4 in the book value changes of 18, and the LIFO method – holding gains of 2 in the book value changes of 16. When the book values of inventories from the business accounts are used to compile the national accounts, the enterprise data should be adjusted to remove only the effects of the holding gains included in these book values. For example, if enterprise data on inventories based on the FIFO method are used, the IVA will be 8, the holding gains included in the business data on inventories, rather than 16, the total amount of holding gains on inventories according to the *1993 SNA*. The IVAs are calculated as the book value changes less the value of changes in inventories.

IV. TECHNIQUES FOR MEASURING CHANGES IN INVENTORIES

As mentioned, changes in inventories pose one of the most difficult measurement problems in the compilation of national accounts and are usually one of their weakest components. The main difficulty arises from the lack of suitable data sources for estimating the value of changes in inventories according to the national accounts definition and valuation principles. For the national accounts, changes in inventories are not merely the difference between the closing and opening values of inventories either from the balance sheets in the national accounts themselves or from the balance sheets in the business accounts.

As previously mentioned, for national accounts the value of changes in inventories in a certain accounting period is given by the sum of all entries and withdrawals from the inventories when each transaction is valued at the prices prevailing at the time they take place. In general, statistical agencies may only obtain book values of inventories at certain dates from the enterprises' accounts, usually at the beginning or end of each quarter or year, or quantities and prices of goods held in inventories. Therefore, national accountants have to resort to specific techniques and assumptions to derive approximate measures of changes in inventories from these available data sources.

When data on stocks of inventories are available, a common statistical technique to derive changes in inventories can be described as follows. First, a change in the volume of inventories during the accounting period is calculated. The change in the volume of

inventories can be derived either as a change in quantities (when quantities of inventories are available) or as a change in deflated values of inventories (when values of the stocks of inventories are available). Second, the quantity change is multiplied by an average price of the product for the accounting period. In the case where volume change is derived from deflated values of inventories, the volume change is multiplied by an average price index for the accounting period (this price index should have the same reference period as that used to deflate the stocks of inventories). The valuation of the change in the volume of inventories at the average prices of the product in inventories is also called the *value of physical change in inventories*. However, as will be explained in the following sections, only under specific conditions will these techniques provide an accurate estimate of changes in inventories required by the *1993 SNA*. This chapter describes the techniques and their underlying assumptions and deficiencies for most common data-situations. It also discusses some specific compilation issues when applying these techniques. These techniques relate, respectively, to two data-situations,

    i.   if quantities of inventories at the opening and closing of accounting periods are available, and

    ii.   if book values of the stocks of inventories are available.

The same main principles, as mentioned in the above paragraph, apply to the statistical techniques under both data-situations. However, the techniques applicable for data-situation (i) are simple and those related to data-situation (ii) are more complex. It should be noted that both these techniques are short-cut methods which use data that are more likely to be or readily available. Improvements to the measurement of changes in inventories that meets the *1993 SNA* requirements are proposed in Section V.

A. If Quantities at the Opening and Closing of Accounting Periods Are Available

If only quantities of inventories at the beginning and end of a period are available, the change in quantities is multiplied by an average price of the products held in inventories during the period to obtain the value of changes in inventories. In this paper, we call this method a *quantity revaluation method*.

It is worth noting that if quantities and market prices for each transaction in inventories (entries and withdrawals) would be known, the estimate of change in inventories for national accounts could be calculated by using the perpetual inventory method (PIM) as required by the *1993 SNA*. In such a case, the value of changes in inventories is derived as

$$\Delta S = \sum_{i=1}^{n} p_i * q_i - \sum_{j=1}^{m} p_j * q_j \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

    where ΔS is the value of changes in inventories, p_i and q_i are the market prices and quantities of entries into inventories, and p_j and q_j are the market prices and quantities of withdrawals, respectively.

The *quantity revaluation method* will provide a measure of changes in inventories according to the *1993 SNA* in specific circumstances. If the price of a product remains constant during the period, the results of this method and the PIM will be the same. This is an unique situation that we will not examine further. If prices are changing, the *quantity revaluation method* will provide the *1993 SNA* measure of changes in inventories only when the quantity of inventories changes at a constant rate or by a constant amount. The following mathematical formulation will help to illustrate this conclusion.

Let Q_o and Q_t be the stocks of inventories held at the beginning and end of a period. Then,

$$Q_t = Q_0 + \left(\Sigma q_i - \Sigma q_j \right)$$

or .... (2)

$$Q_t - Q_0 = \left(\Sigma q_i - \Sigma q_j \right)$$

The average prices of transactions in inventories for additions and withdrawals, respectively, are:

$$\overline{P}_i = \frac{\sum_{i=1}^{n} piqi}{\sum_{i=1}^{n} qi} \quad \text{and} \quad \overline{P}_j = \frac{\sum_{j=1}^{m} pjqj}{\sum_{j=1}^{m} qj} \quad \ldots\ldots\ldots (3)$$

which can be rewritten as:

$$\overline{P}_i = \sum_{i=1}^{n} pi * \frac{qi}{\sum_{i=1}^{n} qi} \quad \text{and} \quad \overline{P}_j = \sum_{j=1}^{m} pj * \frac{qj}{\sum_{j=1}^{m} qj} \quad \ldots\ldots\ldots\ldots(4)$$

By definition, $pi = pj$ for a product at a given time. Additions to as well as withdrawals from the inventory of a finished good at any point in time should be valued at the market price prevailing at that time.

If i and j are considered as a number of time intervals (say a day, week, or month within a longer accounting period) during each of which prices do not change, then $n = m$, and qi and qj indicate quantities of additions and withdrawals, respectively in each interval.

In the condition that the weights of additions and those of withdrawals {shares of quantities added (withdrawn) in each interval out of total quantities added (withdrawn) during the accounting period} in each interval are the same,

$$\frac{qi}{\sum\limits_{i=1}^{n} qi} = \frac{qj}{\sum\limits_{j=1}^{n} qj} \quad \ldots\ldots\ldots\ldots (5)$$

the average prices of additions and the average prices of withdrawals in an accounting period will be equal, i.e.,

$$\overline{P}_i = \overline{P}_j$$

Then, equation (1) can be written as

$$\Delta S = \sum_{i=1}^{n} \overline{P} * qi - \sum_{j=1}^{n} \overline{P} * qj = \overline{P} * \left(\sum_{i=1}^{n} qi - \sum_{j=1}^{n} qj \right) = \overline{P} * \left(Q_t - Q_o \right) \quad \ldots\ldots\ldots\ldots (6)$$

In other words, under the condition of equation (5), the current price value of changes in inventories according to the *1993 SNA* is identical to the change in quantities during the period multiplied by the average prices of the products held in inventories during the period.

The average prices are an average of the transaction prices weighted by the quantities transacted at each price. The average prices for additions will be equal to those for withdrawals only when the weights of additions and withdrawals {shares of quantities added (withdrawn) in each interval out of total quantities added (withdrawn) during the accounting period} in each interval are the same [see equation (5)]. These weights are the same in each interval only when both the additions and withdrawals change at a same constant rate over the accounting period or each of them changes with a constant number.

The volume measure of changes in inventories following the *quantity revaluation method* is derived by multiplying the quantity change by the annual average prices in the base year. The procedures followed in the calculation of changes in inventories using the *quantity revaluation method* is presented in the Appendix.

If changes in quantity of inventories fluctuate, the *quantity revaluation method* would provide only an approximation to the *1993 SNA* measure of changes in inventories. This is because an inventory fluctuation would lead to different average prices for additions and withdrawals whereas the *quantity revaluation method* would use an average price that assumes that inventory changes are constant. In practice, the average prices are usually calculated as a simple arithmetic mean of all prices (or monthly indices) over the accounting

period, which assumes that the weights of both additions and withdrawals are the same in all intervals (for example, months) within an accounting period.

The more inventory fluctuates within an accounting period, the less accurate would be the estimate of changes in inventories derived from the *quantity revaluation method*. The numerical example in Box (7) illustrates the shortcomings of this method for estimating the changes in inventories when quantities of inventories fluctuate.

Box 7. Fluctuating Pattern of Inventories and Estimates of Changes in Inventories

	Opening Stock	Transactions in Each Interval				Closing Stock
		I	II	III	IV	
Quantities	2	(-) 1	(+) 1	(-1)	(+) 2	3
Prices	2.0	3.0	4.0	5.0	6.0	6.0
Value	4.0	(-) 3.0	(+) 4.0	(-) 5.0	(+) 12.0	18.0

Average prices for additions	(4*1+6*2)/3 = 5.33
Average prices for withdrawals	(1*3+1*5)/2 = 4.00
Simple average of all prices	(3+4+5+6)/4 = 4.5
Change in quantity	(3-2) = 1
Value of quantity change at simple average prices	(1*4.5) = 4.5
1993 SNA value of changes in inventories	(4+12) – (3+5) = 8

The "estimated" value of the changes in inventories using the *quantity revaluation method* differs from the *1993 SNA* value of the changes in inventories because additions and withdrawals have different average prices when quantities in inventories fluctuate within the accounting period. In practice, inventories are subject to fluctuations related, inter-alia, to cyclical and seasonal phenomena.

In some cases, only prices at the beginning and end of the accounting period are available. In such cases, the average prices of goods held in inventories may be calculated as a simple average of the prices at the beginning and end of the period, which is less satisfactory than the average of all prices during the accounting period.

A measure of changes in inventories at current prices that satisfies the *1993 SNA* concept or provides a good approximation, can be obtained by calculating them for shorter periods.[6] It is

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[6] The shortcomings of this method to derive an appropriate volume measure of changes in inventories are discussed in Section V.

more likely that the assumptions used by the *quantity revaluation method* regarding inventory and price movements will hold for shorter periods. For example, if inventories of a group of goods swings quarterly, although the opening and closing inventories for the year may remain unchanged the quarterly data will show fluctuating inventory levels.

For obtaining more accurate estimates, inventory valuation adjustments should be performed for shorter time periods, on a monthly or at least on a quarterly basis. The changes in inventories at current prices for a longer period (a year) should be derived by summing the changes in inventories at current prices for shorter periods (months or quarters as appropriate).

B. If Book Values of the Stocks of Inventories Are Available

The techniques for deriving the estimates of changes in inventories based on the book values of opening and closing inventories have to depend on the accounting methods for inventories used by enterprises. When prices are changing, the book values of the stock of inventories will reflect different prices (or prices at different times) under the FIFO, weighted-average cost, and LIFO methods (see Box 5). While the techniques followed if book values based on the FIFO and weighted-average cost methods are available are largely the same, a different approach should be applied in the case of LIFO-based book values.

The FIFO and weighted-average-cost cases

Calculation procedures in general

Similar to the case when quantities of opening and closing dates are available, the essence of the procedures that use book values of inventories is to obtain an estimate of the current value of the physical change in inventories as an approximation to the *1993 SNA* value of changes in inventories. The following steps are involved:

1. The book values of inventories at the opening and closing dates of the period are converted to base period prices.[7] For this purpose, appropriate deflators need to be calculated for converting the book values of inventories into constant price values.

2. The difference between the constant price values of the stocks of inventories at the beginning and end of the period provides an estimate of the volume change in the stock of inventories at base period prices. In principle, this notion is equivalent to the

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[7] The technique requires that opening and closing book values of stock are revalued at the same price. In principle, this could be any price, even the average market price of the current period. However, for calculating changes in inventories at constant prices following this technique, it is convenient to make the revaluation at the annual average prices of the base year (previous year in case of annual chain indices).

change in quantities of inventories between the beginning and end of an accounting period.

3.   The volume change in the stock of inventories at base period prices is multiplied by an average price index for the current accounting period (this price index should have the same reference period as that used to deflate the stocks of inventories) to obtain an estimate of the changes in inventories at current prices. In principle, this process is equivalent to the *quantity revaluation method* where the quantity change in inventories during a period is multiplied by the average prices of the current period.

The general procedure can be symbolically expressed as follows:

$$\Delta S_{t/x} = S_{n/x} - S_{0/x} \quad \ldots\ldots\ldots\ldots (7)$$

where (x) is the base period and $S_{n/x}$ and $S_{0/x}$ are the values of the level of inventories at the end (n) and beginning (o) of an accounting period at base period prices, and $\Delta S_{t/x}$ is the volume change in the stock of inventories at base period prices.

Under this technique, $\Delta S_{t/x}$ is taken as the volume measure of changes in inventories (constant price values) if annual average prices are used as the base period prices.

The book values are converted to base period prices by deflating them by specially constructed price indices referred to period (x) as follows:

$$S_{n/x} = S_n / IP_{n/x} \quad \ldots\ldots\ldots\ldots (8)$$
$$S_{0/x} = S_0 / IP_{0/x} \quad \ldots\ldots\ldots\ldots (9)$$

where S_n and S_0 are the book values of inventories at the end and at the beginning of an accounting period; and, $IP_{n/x}$ and $IP_{o/x}$ are corresponding deflators for these book values of inventories.

The changes in inventories at average prices of the current period following this technique are obtained as,

$$\Delta S_t = \Delta S_{t/x} * IP_{t/x} \quad \ldots\ldots\ldots\ldots (10)$$

where $IP_{t/x}$ is the average price index of the goods held in inventories in period (t) referred to the base period (x).

The procedures followed in the calculation of changes in inventories using the book values of inventories under the FIFO cost accounting method is presented in the Appendix.

The main issue in the application of the above technique relates to the calculation of the deflators for the opening and closing book values of inventories. The remainder of this section describes the techniques for deriving the deflators for the book values of inventories.

Derivation of deflators for book values

Under historic cost valuation, deriving deflators for book values of opening and closing inventories implies taking into account that these values are implicitly based on a self-weighting average of the prices of the products at the time they entered into the inventories. These values can be seen as the sum of the values of the remaining quantities held from different vintage groups of entries, which themselves can be seen as the products of the remaining quantity and the price at the time of entry. Thus, to derive deflators for the book values of opening and closing inventories, weights and price data of the component products are needed for each vintage.

Unfortunately, usually no data are available for the weights of various vintage groups in the opening and closing stocks because --except for cases in which maturing of products is part of the production process-- vintage is not of great interest to producers. However, an approximation can be made using data on stock holding periods.

The next subsections describe how stock holding periods are calculated, how price data can be derived, and how they can be used to construct deflators. Because the vintage structure of inventories is different under FIFO and weighted-average cost methods, a different procedure for deriving the deflators under each business inventory accounting method will have to be used.

Stock holding period

As mentioned, the prices underlying the book value of inventories are a weighted averages of prices of goods in inventories which were acquired at different times. Ideally, it is necessary to know the holding time for each unit held in inventories. As such information is rarely available, the average holding period for the goods in inventories can be used as an approximation. As holding periods provide weights for combining prices of goods held in inventories, they should reflect proportions of the quantity (volume) of goods acquired in different sub-periods in the total inventory held at a point in time. This subsection deals with general issues related to the stock holding period of inventories. The derivation of weights under the FIFO and weighted-average cost methods is described later in subsections on aggregation procedures for deflators.

The average holding period of the inventory for a specific good is the average number of months during which items remain in inventories before they are withdrawn (before the items are sold, completed, or used as the case may be).

The average holding period is usually derived in terms of months. It can be calculated by counting the number of months worth of entries (production in the case of output and

purchases in the case of goods for resale and raw materials) required to make up the inventory. Calculations can be performed using monthly, or quarterly, or annual data. For instance, if quarterly data are used, monthly averages of inventory additions over the quarters are calculated, and the holding period is estimated as the number of months worth of these average monthly additions required to make up the inventory. Clearly, monthly data provide more accurate estimates of the holding period for the items held in inventories at each point in time than quarterly data. Estimates of holding period based on annual data would be least desirable. Numerical examples in Box (8) and (9) show how weights can be derived using enterprises' financial data under the FIFO and weighted-average cost methods respectively.

Several factors affect the accuracy of the estimated holding period and weights, particularly when low frequency data are used to estimate it. These factors and their effects can be summarized as follows.

- When prices are changing, the prices underlying the book value of the stock of inventories and the flow of entries may differ, which leads to the over- or underestimation of the holding period. The difference between the prices underlying the flows and stocks are also affected by enterprise accounting practices. The FIFO method values stocks at the prices of the periods close to the end of the period. The book value of stocks under the weighted-average cost method includes prices of a longer period than the FIFO method.[8]

- Using average monthly flows of entries into inventories (rather than discrete monthly flows) assumes that inventories are formed continuously and uniformly over the holding period. Furthermore, there may be different paths of stock building that match a given average holding period of inventories.

- The estimate of an accurate holding period is further complicated if the product composition of the inventories is not known. An average holding period for the total of inventories may imply different holding periods for individual goods. Even under the assumption of a uniform path of stock building for each individual good, the proportion of total inventories acquired in more recent periods will be higher than that acquired in earlier periods. This is because under FIFO goods acquired shortly before the closing date are more likely to be still in stock than goods acquired earlier. The calculation of average holding periods using aggregated stocks of inventories would

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[8] It is worth noting that under the LIFO method the prices underlying book values of stocks of inventories may usually relate to periods that are significantly earlier than the periods to which the prices of the recent flows of entries refer. Therefore, the book values under LIFO method can not be used to determine holding periods unless information on the time of acquisitions of inventories remaining in stocks is known so that prices underlying the book values can be aligned with the prices of flows in the current or recent period.

therefore underestimate the proportion of inventories acquired in the most recent months, overestimate the proportion of inventories acquired in earlier months, and discard some inventories acquired in the earliest periods. In order to deal with this problem, some arbitrary weighting patterns giving higher importance to the most recent periods are sometimes assumed by compilers.

• Due to changing inventory patterns over time, the holding period for the stocks at the beginning of a period will usually differ from that for the stocks at the end of the period. Therefore, the holding periods should be calculated independently for opening and closing stocks.

The choice of price indices for the calculation of deflators

Price indices used to construct the deflators for the book values of inventories should have the same price concept as that used to value the flows of inventories. Thus, for inventories of finished goods held by producers, the price index should measure the changes in the basic prices of the goods held in inventories; for materials and supplies, the price indices should reflect the changes in the purchaser's prices; and, for work-in-progress, the prices should be the basic prices of these products. Inventories of goods for resale, mainly held by wholesale and retail trade enterprises, should be deflated by their respective purchasers' price indices.

It is preferable to construct the deflators for book values of inventories at disaggregated levels to take into account differences in holding periods and price movements among various groups of products. Even at the disaggregated level, inventory groups usually comprise many different products. Therefore, deflators at each group level should be built up as weighted averages of price indices for products covered in that group. Since current information on product composition will not usually be available, the product weights might have to be taken from detailed benchmark data on the product composition of inventories. An alternative would be to assume that the commodity composition of the inventories of finished goods is the same as the commodity composition of output. Likewise, the commodity composition of the inventories of materials and supplies is usually assumed to be the same as that of the purchases or consumption of these goods.

Aggregation procedures for deflators of book values

The FIFO case

The FIFO valuation of inventories implies that the prices used for the valuation of the inventories at any given point of time are the prices of the latest acquisitions. Considering a single item held in inventories, the prices relevant for this item are the prices at which the units held in inventories were acquired. Assuming that inventories are held for (k) months, the deflator for the book value of inventories at the end of a certain month would be:

$$\overline{P_{t/x}} = \sum_{t=1}^{k} p_{t/x}^{*} w_t \quad \dots\dots\dots (11)$$

where, $P_{t/x}$ are the monthly price indices with period x=100 for the item held in inventories, t refers to the months during which the inventories are built-up, and (w_t) represents the proportions of the quantity of inventories acquired in each month which remain in the stock.

When deflators are derived for a group of products in inventories, the $P_{t/x}$ should be a weighted monthly average of price indices representing the composition of goods held in inventories.

The weights (w_t) are usually calculated using financial data reported by enterprises. The example in Box (8) shows calculations of weights based on the information on stock holding periods. In the example, stock holding periods are calculated from data on monthly additions to inventories by commodities. If monthly data are not available, a monthly average from quarterly data will have to be used to estimate holding periods.

In practice, however, a commodity breakdown may not be available. In such a case, only an average aggregate holding period and weights can be estimated. In the example from Box (8), average aggregate holding period will be equal to 2.76 months which will imply weights as follows: 0.37 for the months (n) and (n-1) and 0.26 for the month (n-3). Calculating the holding period using aggregate data will generally overvalue the weights of the most recent periods and will neglect the weights of the earliest periods.

	Inventory at the end of month n	Additions by month				Estimated holding period in months	Assumed inventories distribution by vintage			
		n	n-1	n-2	n-3		n	n-1	n-2	n-3
Commodity 1	100	60	40	55	38	2.00	50	50		
Commodity 2	300	90	90	80	70	3.42	87.7	87.7	87.7	36.8
Commodity 3	170	80	70	60	50	2.33	73	73	24	
Total	570	230	200	185	158	(2.76)	210.7	210.7	111.7	36.8
Weights							0.37	0.37	0.19	.07

Box 8. Example on the Calculation of Holding Period of Inventories and Weights

Notes: The estimated holding period for each commodity is calculated as the number of monthly additions that make up and remain in the inventories. Thus, for commodity (1) the inventory (100) worth two months of additions [60 units in month (n) and 40 units in month (n-1)]. For commodity (2), the inventory (300) is made up from the additions in months (n), (n-1), (n-2), and 42% of additions in month (n-3). Therefore the holding period for this commodity is 3.42. Based on monthly averages from quarterly data, the holding periods for commodities 1, 2, and 3 will be respectively 1.94 [100/{(60+40+55)/3}], 3.46 [300/{(90+90+80)/3}], and 2.43 [170/{(80+70+60)/3}].

Based on the information on holding periods, the assumed inventory distribution by vintage is derived by distributing the inventory evenly over the stock holding period. Thus for commodity (1), it is assumed that the 100 units held in inventories at the end of period (n) are composed by 50 units of the (n) vintage and 50 units of the (n-1) vintage. The weights for the entire inventory are calculated by diving the total assumed acquisition of inventories in each month by the total stock of inventories (for example 210.7/570=0.37).

The moving weighted-average case

The prices underlying the book value of inventories based on a moving weighted-average cost method at any point of time are an average of the price of the last acquisition and the average prices of the stock prior to the last acquisition. The latter is calculated as the average of the price of the acquisition prior to the last acquisition and the average prices of the stock before the second last acquisition. Thus, under the moving weighted-average cost method an average price of the inventory is calculated every time an item is added to the inventory. To approximate the prices underlying the book values of inventories implicit in this method of enterprise valuation, the following algorithm can be used.

Let $\overline{P}_t$ be the average price of the book value of inventories at the end of month (t), and (P_t) the average current market price of the goods acquired in inventories in month (t). If Q^S_t is the quantity held in inventories at the end of period (t), and Q^A_t is the quantity added (acquisitions) during period (t), then the average book keeping price of the inventories at the end of period (t) is:

$$\overline{P}_t = \overline{P}_{t-1} * \frac{Q^S_{t-1}}{Q^S_{t-1} + Q^A_t} + P_t * \frac{Q^A_t}{Q^S_{t-1} + Q^A_t} \quad \dots\dots\dots\dots (12)$$

Let the weights of quantities held in inventories be denoted by W_S and the quantities acquired in each period by W_A. Under a simplified model of inventory building, where quantity held in inventory remains unchanged, both weights remain constant over time. In that case, the average bookkeeping price at the end of each period can be expressed as follows[9]:

$$\overline{P}_t = w_S * \overline{P}_{t-1} + w_A * P_t \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots (13)$$

$$\overline{P}_{t-1} = w_S * \overline{P}_{t-2} + w_A * P_{t-1} \quad \dots\dots\dots\dots\dots\dots\dots\dots (14)$$

$$\vdots$$
$$\vdots$$

$$\overline{P}_{t-n} = w_S * \overline{P}_{t-(n+1)} + w_A * P_{t-n} \quad \dots\dots\dots\dots\dots\dots\dots (15)$$

Replacing in (13) the value of $\overline{P}_{t-1}$ by (14), and then successively replacing the average book keeping prices of the inventories for each earlier period with its respective price formula, we would have:

$$\overline{P}_t = w^n_S \overline{P}_{t-n} + w_A w^{n-1}_S P_{t-(n-1)} + w_A w^{n-2}_S P_{t-(n-2)} + \dots + w_A w_S P_t \quad \dots\dots\dots\dots (16)$$

As $0 < w_S < 1$, w^n_S tends to zero when (n) becomes large. That is, prices of previous periods have a decreasing weight in the formation of the average book keeping price of inventories. Therefore, for practical purposes the first terms of equation (16) may be discarded when (n) is sufficiently large.

The values of w_S and w_A depend on the holding period of the inventories. The holding period (k) in terms of months may be estimated using one of the approaches discussed earlier in this chapter.

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[9] Similar formulas for determining weights can be developed for other known cases of inventory changes. One particular case could be where additions and withdrawals of inventory change proportionately.

Expressing the quantities held in inventories in terms of acquisitions, the weights of the stock of inventories and additions given in (12) would be:

$$w_s = \frac{Q_S}{Q_S + Q_A} = \frac{k * Q_A}{k * Q_A + Q_A} = \frac{k}{k+1} \quad \text{.............................. (17)}$$

and,

$$w_A = \frac{Q_A}{Q_S + Q_A} = \frac{Q_A}{k * Q_A + Q_A} = \frac{1}{k+1} \quad \text{.............................. (18)}$$

where, $w_S + w_A = 1$

The book keeping prices of the inventories can be calculated by replacing in (16) the values of w_s and w_A from equations (17) and (18), respectively for inventories with different holding periods. The numerical example in Box (9) illustrates, with an assumed holding period of two months, the determination of the weights for aggregating prices of different periods.

Box 9. Moving Weighted-Average-Cost Method of Inventory Valuation: Calculation of Weights for Prices of Inventories with a Two-Month Holding Period

Period	Weights		Adjusted weights
t	w_A $= 1/3$	$= 0.33$	0.3300
t-1	$w_A * w_S = 0.33 * 0.67$	$= 0.2211$	0.2210
t-2	$w_A * w_S^2 = 0.33 * (0.67)^2$	$= 0.148137$	0.1481
t-3	$w_A * w_S^3 = 0.33 * (0.67)^3$	$= 0.099252$	0.0993
t-4	$w_A * w_S^4 = 0.33 * (0.67)^4$	$= 0.066498$	0.0665
t-5	$w_A * w_S^5 = 0.33 * (0.67)^5$	$= 0.044554$	0.0446
t-6	$w_A * w_S^6 = 0.33 * (0.67)^6$	$= 0.029851$	0.0299
t-7	$w_A * w_S^7 = 0.33 * (0.67)^7$	$= 0.020000$	0.0200
t-8	$w_A * w_S^8 = 0.33 * (0.67)^8$	$= 0.013400$	0.0160
t-9	$w_A * w_S^9 = 0.33 * (0.67)^9$	$= 0.008978$	0.0140
t-10	$w_A * w_S^{10} = 0.33 * (0.67)^{10}$	$= 0.006015$	0.0115
SUM			1.000

Notes: The weights of stocks and additions are determined applying the equations (17) and (18). Data have been arranged on a decreasing order of weights, i.e., from the current to the earliest periods. In the last column, the weights of the recent months are normalized so that the weights sum to the value of one as most earliest months have insignificant weights.

A numerical example for the calculation of the book keeping prices of the stock of inventories is presented in Boxes (10) and (11). In the example, inventories are valued using a moving weighted-average-cost method. For the sake of illustration, the bookkeeping monthly data for a whole year is given with a detailed breakdown of the transactions in its quantity, price, and value components. These detailed bookkeeping entries together with the bookkeeping calculation of the weighted average prices of book values of inventories are presented in Box (10).

Box 10. Calculation of the Bookkeeping Average Price of Inventories That Use Moving Weighted-Average-Cost Method With a Holding Period of Two Months: Detailed Book Keeping Entries and Calculation of Bookkeeping Prices

Period	Opening inventories			Acquisitions			Withdrawals			Closing inventories		
	Quantity	Price	Value	Quantity	Price	Value	Quantity	Price	Value	Quantity	Price	Value
t-1										100	1.00000	100.000
t=1	100	1.00000	100.000	50	1.25000	62.5000	50	1.08333	54.1667	100	1.08330	108.333
2	100	1.08330	108.330	50	1.56250	78.1250	50	1.24306	62.1528	100	1.24306	124.306
3	100	1.24306	124.306	50	1.95313	97.6563	50	1.47975	73.9873	100	1.47975	147.975
4	100	1.47975	147.975	50	2.44141	122.0700	50	1.80030	90.0149	100	1.80030	180.030
5	100	1.80030	180.030	50	3.05176	152.5880	50	2.21745	110.873	100	2.21745	221.745
6	100	2.21745	221.745	50	3.81470	190.7350	50	2.74987	137.493	100	2.74987	274.987
7	100	2.74987	274.987	50	4.76837	238.4190	50	3.42270	171.135	100	3.42270	342.270
8	100	3.42270	342.270	50	5.96046	298.0230	50	4.26862	213.431	100	4.26862	426.862
9	100	4.26862	426.862	50	7.45058	372.5290	50	5.32928	266.464	100	5.32928	532.928
10	100	5.32928	532.928	50	9.31323	465.6610	50	6.65726	332.863	100	6.65726	665.726
11	100	6.65726	665.726	50	11.64150	582.0770	50	8.31868	415.934	100	8.31868	831.868
12	100	8.31868	831.868	50	14.55190	727.5960	50	10.39640	519.821	100	10.39640	1039.640

Note: The weighted average price underlying the book value of the closing inventories at the end of the period based on enterprise records is 10.3964.

In practice, only book values of stocks of inventories are available and appropriate prices or price indices will have to be chosen by the compilers of national accounts statistics. Box (11) shows the derivation of the weighted average price implicit in the book value of inventories at the end of the period using the weights determined in Box (9).

Box 11. Calculation of the Bookkeeping Average Price of Inventories That Use Moving Weighted-Average-Cost Method With a Holding Period of Two Months: Calculation of the Estimated Weighted Average Price for the Book Value of the Inventory

Period (month)	Weight	Average Prices	Contribution to average price
$t = 12$	0.3300	14.55190	4.802130
$t-1 = 11$	0.2210	11.64150	2.572770
$t 2 = 10$	0.1481	9.31323	1.37929
$t-3 = 9$	0.0993	7.45058	0.73984
$t-4 = 8$	0.0665	5.96046	0.39637
$t-5 = 7$	0.0446	4.76837	0.21267
$t-6 = 6$	0.0299	3.81470	0.114060
$t-7 = 5$	0.0200	3.05176	0.06104
$t-8 = 4$	0.0160	2.44141	0.03906
$t-9 = 3$	0.0140	1.95313	0.02734
$t-10 = 2$	0.0116	1.56250	0.018130
Weighted average			10.3627

Notes: The estimate of the weighted average price for the book value with the holding period of two months is based on the average prices for each intervals (Box 10), say months, and the system of weights from Box (9). The acquisition prices in Box (10) represent the current transaction prices of products in each interval. The estimated weighted average price (10.36271) closely approximates the true average price underlying the book value of inventory (10.3964) calculated from the detailed book keeping entries (see Box 10). It could be noted that if the estimated price of the closing inventories were to be calculated assuming a FIFO inventory valuation, the estimated average price would be 13.1 ((14.5519+11.6415)/2), significantly higher than the average price implicit under the weighted-average cost method.

Specific issues in techniques for FIFO and weighted-average-cost methods

As in the case of quantity revaluation method, statistical techniques that use book values of inventories will yield a measure of changes in inventories at current prices that satisfies or provides a better approximation to the *1993 SNA* concept by calculating them for shorter periods. For obtaining more accurate estimates, inventory valuation adjustments should be performed for shorter time periods, on a monthly or at least on a quarterly basis. The changes in inventories at current prices for a longer period (a year) should be derived by summing the

changes in inventories at current prices for shorter periods (month or quarter as appropriate). However, this approach will not provide a satisfactory estimate of the volume measures of changes in inventories that fulfils the *1993 SNA* accounting principles (see Section V for the main reasons and a solution).

Composition of inventories affects the calculation of average holding periods. Therefore, estimation of changes in inventories should be made at a most detailed level of classification (by type of inventories, then by economic activities, and then by major products or groups of products). Inventory valuation adjustments at a detailed level will also allow to measure more accurately the effects of changes in prices as the changes in prices of different types of inventories usually vary. Price movements are more likely to be homogeneous at a more detailed level.

The LIFO case

Under the LIFO method of inventory valuation, enterprises record withdrawals from inventories at the prices of the latest acquisitions. When inventories are stable or rising during the accounting period, the prices of the items withdrawn are likely to represent current prices because none of the older items in inventory are withdrawn. In most cases when inventories are uniformly distributed during the accounting period, enterprise accounting of transactions in inventories (entries and withdrawals) would match the valuation concepts of the national accounts, and hence, valuation adjustment to the reported financial data on book value changes in inventories would not be needed. However, the prices of the items last acquired may not exactly represent the current prices depending on the holding period and inflation during that period even if the inventory is not decreasing. This will cause a problem, particularly, in a high inflation situation. Then, the LIFO method may introduce holding gains in value added.

A different situation occurs with the LIFO valuation when quantities in inventories are decreasing since part of the withdrawals will be valued at historic prices of items acquired in earlier periods. As a result, financial data reported by enterprises may include substantial holding gains.

Estimating the holding period from the book keeping data is not possible under the LIFO method because of the long time lag of the historic prices implicit in the book value with respect to the prices of the current period. Therefore, the estimation of holding gains requires independent information on the holding period. Information on the periods during which inventories are accumulating and de-cumulating is needed to determine whether holding gains occur. In cases where holding gains are occurring, information on what prices (from which periods) to use for making the inventory valuation adjustment is also needed. Two approaches may be used to estimate the changes in inventories when inventories are decumulating: (i) by requesting enterprises to supply data on quantities of inventories together with prices of the main products held in inventories, which would allow to use the *quantity revaluation method*; or (ii) by estimating the time periods in which the withdrawn goods were acquired, and then revaluing the book value decrease in inventories using appropriate price indices for deriving the

value of withdrawals at the current replacement prices. It would be possible to determine the time periods during which the goods withdrawn in the current period were acquired if a sufficiently long time series of book values of inventories with reasonably high frequency of interval (at least quarterly) is available.

V. IMPROVING THE MEASUREMENT OF CHANGES IN INVENTORIES

Any statistical technique for estimating the changes in inventories that uses data on the opening and closing inventories, as discussed in the previous section, can only produce the correct measure of these transactions at current prices if inventories are changing at a constant rate or by a constant amount. In practice, inventory fluctuations could be volatile reflecting seasonal and technical factors as well as economic decisions. Applying the statistical techniques described in the previous section for shorter periods will increase the accuracy of the estimates of the changes in inventories at current prices. However, these procedures will not provide a correct volume measure of changes in inventories according to the *1993 SNA* if inventory movements are occurring and prices are changing over a longer period (a year, because volume measures are derived using annual prices).[10] A related issue is also the interpretation of data on changes in inventories. The following subsections describe the conceptual basis for deriving volume measures of changes in inventories, explain the interpretation of data on changes in inventories, and suggest methods for measuring changes in inventories both at current prices and in volume terms according to the *1993 SNA*.

A. Conceptual Basis for Volume Measures of Changes in Inventories

Calculations of volume measures or constant price estimates in the national accounts imply revaluation of each specific transaction in goods and services using the weighted average price of the respective transactions during the base period (the base year price). Therefore, for the base year, estimates at current prices and at prices of the base year are identical.

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[10] It is worth mentioning here that when statistical techniques described in Section IV are used to estimate changes in inventories at current prices by calculating them for shorter periods and deriving the annual data at current prices by summing the data for shorter periods, the annual estimate at current prices may generally differ from the annual estimate in volume terms for the base year. Conceptually, for the base year, estimates at current prices and at the prices of the base year should be identical. Out of the current price and volume measures, the estimate for the former is correct or more accurate. The main reason for this is that the current price measures are calculated using prices for shorter periods (it is more likely that average prices of additions and of withdrawals for shorter periods are same or close) while volume measures are calculated using annual prices of the base year (the annual average prices for additions will usually differ from those for withdrawals).

Conceptually, the volume measures of changes in inventories should be calculated through separate revaluations of additions to and withdrawals from inventories to the base year prices. Consequently, estimates of volume measures of changes in inventories should be obtained as the volume measures of additions to inventories less the volume measures of withdrawals from inventories.

Separate revaluations of additions and withdrawals are needed to obtain the volume measure of the changes in inventories because only separate deflators for additions and withdrawals are meaningful. An implicit deflator underlying the changes in inventories (rather than the additions and withdrawals separately) may be undefined or may take a value (positive or negative) that is out of the range of observed prices during the accounting period.[11] This is because the changes in inventories reflect not only movements in inventories but also an element of valuation adjustment, which makes it difficult.to disentangle quantity from price changes. As a result, implicit price for changes in inventories (defined as the current value of changes in inventories divided by the change in quantity of inventories) may be meaningless and counter intuitive. A specific case that clearly exemplifies this fact is a situation when quantities of opening and closing inventories remain unchanged but the current value of changes in inventories is not zero because of inventory movements and price changes during the accounting period.[12]

B. Interpretation of Changes in Inventories

The discussion in the above subsection suggests that a careful interpretation is needed of the aggregate of changes in inventories. Unlike other flows of goods and services (such as output, household final consumption expenditures, etc.) which measure changes in underlying volumes and their prices, the changes in inventories include also the effect of holding gains on products held in inventories. Therefore, the national accounts data on changes in inventories may not be suitable for gauging the changes in the level of inventories. For certain analytical uses where an indicator of physical stocks or changes in physical stocks of inventories is needed (for example, to study stock that firms desire to hold for a given volume of sales), data on stocks of inventories converted into a base price (typically annual average prices of the base year) would be most relevant. The techniques presented in Section IV can be used for converting book values of the stock of inventories, under different business inventory accounting practices, into a base price.[13] This paper suggests that volume measures of stocks of inventories (classified by

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[11] The weighted average prices for both the additions and withdrawals are the same when the proportions of additions and withdrawals of each interval, during which prices remain unchanged, in the total additions and withdrawals, respectively, are equal. In this case, this average price is also the implicit price or deflator underlying the change in inventories.

[12] It can be seen from Box (3) that the physical change in inventory of materials is zero while the value of the change in inventory is (-10).

[13] Although the *1993 SNA* mentions that changes in values of stocks of many kinds of assets can usually be decomposed into their own price and volume components (*1993 SNA*: 16.2), it does

types and economic activities) be compiled and disseminated as an integral part of national accounts statistics.

C. Improvements in the Measurement of Changes in Inventories

The estimates of the changes in inventories that meet the *1993 SNA* principles for the valuation and recording of transactions in inventories can be obtained by measuring (or approximating) separately the flows on entries into the inventories and on withdrawals from the inventories. This approach will provide correct measures of changes in inventories both at current prices and in volume terms. As a result, GDP at current prices and in volume terms will provide a correct measure of production by excluding the effects of holding gains on their measurement.

Accordingly, this paper proposes that the estimates of the changes in inventories should be based on separate calculations of additions and withdrawals of inventories. As a practical approach, this method should be followed for important inventories in economic activities that hold significant inventories. Where data may be readily available, this method can be introduced in the immediate future. If data are not readily available and inventories are important, efforts should be made to collect necessary information to calculate flows of additions and withdrawals of inventories. If inventories are not significant, an approximate estimate can be obtained by using the techniques described in Section IV.

This subsection describes possible sources and methods for deriving separate data on flows of additions and withdrawals of important types of inventories in a number of economic activities. As inventories are generally significant in wholesale and retail trade and in industries producing goods, the discussion below will emphasize these industries.

Inventories of goods for resale: These inventories are important in wholesale and retail trade. Purchases of goods for resale are additions to inventories and sales of goods are withdrawals from inventories. Information on these flows is readily available from business accounting records, and is often collected in statistical surveys. The changes in inventories at current prices can be calculated directly as purchases (additions to inventories) less sales, including recurrent losses, (withdrawals from inventories) during the accounting period. Each flow should be converted to the base year prices of the respective flow to calculate changes in inventories in volume terms. The base year prices should be derived separately for additions and withdrawals.

Inventories of finished goods: These inventories are relevant in goods producing industries. For these industries, production represents the acquisition of inventories of finished goods or

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not include the compilation of such data within its core framework. The OECD *Measuring Capital: A Manual on the Measurement of Capital Stocks, Consumption of Fixed Capital and Capital Services* provides a framework for the measurement of stocks of fixed capital, including their volume measures.

work-in-progress while sales represents the disposals (withdrawals) of these goods from inventories.

For inventories of finished goods, data on sales as reported by enterprises constitute withdrawals from inventories. Information on additions to the inventories of finished goods, which is equal to the production of finished goods, may be available in cases where data on production (value and/or quantity of production) are collected. Monthly or quarterly data on quantity of production of important commodities are usually collected and available (for example, production of crops and livestock products, production of mines and minerals, manufacture of construction materials and major manufactured products, etc.).

Except for industries where data on production are collected, information on additions to inventories of finished goods (equivalent to the production of finished goods) may not be readily available. With the use of accounting software, information on production of finished goods may be obtainable from enterprise records. However, until such information can be obtained directly from enterprises, an approximate estimate of additions to the inventories of finished goods can be obtained from available data sources. For example, many countries produce monthly production indices which usually cover mining and manufacturing activities. A monthly series of production (representing additions to the inventories of finished goods) at current and base year prices can be derived from these monthly production indices.

Agriculture poses specific issues in recording production. Following the general principles of recording production on an ongoing basis, agriculture production should be measured by applying the work-in-progress concepts. However, the degree of uncertainty about the eventual output raises several conceptual and practical problems in the application of the work-in-progress concept in measuring agriculture production. Many countries, therefore, record crop productions at the time of harvest. In this case, additions to inventories are represented by the value of harvest while withdrawals are represented by the sales from inventories plus other uses (such as, seeds, animal feed, etc.) and recurrent losses. The estimates of additions and withdrawals for crops can be made for each crop.

Inventories of work-in-progress: Work-in-progress is important in agriculture, construction, and manufacturing of goods and production of some services that take long time to complete. Work-in-progress during an accounting period constitutes additions to inventories. Withdrawals from inventories of work-in-progress take place when the production process is completed at which time it is recorded as inventories of finished products. If prices are changing, the entire stock of work-in-progress accumulated since the production started should be revalued to the prices prevailing at the time the production is completed. The calculations of inventories of work-in-progress often involve assumptions regarding the proportions of production completed in each accounting period. Methods and conceptual as well as practical problems in calculating work-in-progress are described in Chapter X of the IMF's *Quarterly National Accounts Manual*, 2001.

Inventories of materials and supplies: These inventories could be significant in most goods producing industries. Acquisitions of inventories of raw materials by producers are registered as

purchases of these goods while uses of these goods in the production process represent withdrawals from inventories.

For the inventories of materials and supplies, data on purchases, which are available in enterprise accounts and collected in statistical surveys, constitute additions to inventories. Withdrawals of inventories of raw materials should represent raw materials used in production valued at the time of their use. Even if enterprises keep detailed records of withdrawals of raw materials and can provide information on these withdrawals, they will be valued at historic prices, but not at the current prices at the time of withdrawals. Only under the LIFO method of inventory valuation, and if inventories are stable or rising during the accounting period, the prices of the items withdrawn are most likely to represent current prices. However, the prices of the items last acquired, under the LIFO method, may not represent the current prices during high inflation.

Several alternative methods can be used to estimate the withdrawals of materials and supplies from inventories.

- One possibility would be to obtain high frequency data (monthly or at least quarterly) on the quantity of raw materials used in production. Appropriate prices or price indices representing current prices and base year prices can then be used to calculate withdrawals of raw materials from inventories at current and base year prices. This approach could be used to estimate the flows on withdrawals of major raw materials.
- When a strong quantitative relationship exists between the use of a raw material and production, the use of that raw material in volume terms can be derived from data on production.
- The estimates of withdrawals of raw materials can also be derived as a residual from the estimates of opening and closing inventories, additions to inventories, and holding gains; all estimated according to the *1993 SNA* principles. Any exceptional losses of inventories during the accounting period should also be taken into account. Opening and closing inventories according to the *1993 SNA* can be derived from the book values of inventories using the techniques described in Section IV of this paper. A good estimate of changes in inventories at current prices can be obtained by applying the statistical techniques described in Section IV for shorter periods. The holding gains are given by the change in balance sheet values minus changes in inventories (exceptional losses should also be deducted from the change in balance sheet values).

VI. CONCLUDING REMARKS

This paper elaborates specific statistical techniques and their underlying assumptions for calculating changes in inventories and holding gains when available data relate to (i) quantities of inventories at the beginning and end of an accounting period, and (ii) book values of opening and closing inventories under various methods of historic cost accounting used by enterprises. These methods, however, produce the correct measure of changes in inventories only when

inventories are changing at a constant rate or by a constant amount. In reality, inventories are likely to fluctuate. This paper concludes that the application of these statistical techniques for shorter periods (say, monthly or quarterly) will increase the accuracy of the changes in inventories at current prices but will not provide a satisfactory measure of changes in inventories in volume terms if inventories are fluctuating.

The authors of this paper suggest that the measures of changes in inventories, both at current prices and in volume terms, that fulfill the *1993 SNA* principles for valuating and recording transactions should be obtained by measuring separately the flows on additions to and withdrawals from the inventories. The paper explores possible sources and methods for estimating separate flows of additions and withdrawals of inventories for important types of inventories in a number of economic activities where inventories tend to be important. Where data may be readily available, this method can be introduced in the immediate future. If data are not readily available and inventories are important, efforts should be made to collect necessary information to calculate separate flows of additions to and withdrawals from inventories.

The authors caution that a careful interpretation is needed of the aggregate on changes in inventories. Unlike other flows of goods and services (such as output, household final consumption expenditures, etc.), which reflect changes in underlying volumes and their prices; the changes in inventories reflect, in addition to movements in inventories and prices, a valuation adjustment arising from the fact that the difference between the prices of the output and the use of a product may include holding gains. Therefore, the national accounts data on changes in inventories may not be suitable for gauging the changes in the level of inventories. For certain analytical uses where an indicator of physical stocks or changes in physical stocks of inventories is needed, data on stocks of inventories converted into a base price would be most relevant. This paper recommends that volume measures of stocks of inventories (classified by types and economic activities) be compiled and disseminated as an integral part of national accounts statistics. The techniques presented in Section IV can be used for converting book values of the stock of inventories, prepared using different business inventory accounting practices, into a base price.

CALCULATION OF CHANGES IN INVENTORIES USING STOCK DATA: A SIMPLE EXAMPLE

This appendix presents simple examples for calculating changes in inventories using data on stocks of inventories. Example (1) shows procedures for estimating changes in inventories at current prices and in volume terms using data on quantities of inventories. Example (2) illustrates procedures for estimating changes in inventories at current prices and in volume terms using data on book values of inventories that are based on the FIFO cost accounting method. In both these examples, the changes in inventories are calculated on a quarterly basis.

Example 1: Calculations of changes in inventories using data on quantities of inventories

Table 1 shows the available information and the calculation procedures used in the estimation of changes in inventories.

Table 1. Calculations of Changes in Inventories Using Data on Quantities of Inventories

Period	Information Available			Calculations		
	Quantities		Average prices of the period	Change in quantity	Changes in inventories	
	Opening	Closing			at current prices	at base year (t) prices
Year (t)	20	32	7.00			
Year ($t+1$)						
Q1	32	35	10.00	3	30.0	21.0
Q2	35	30	10.50	-5	-52.5	-35.0
Q3	30	28	11.00	-2	-22.0	-14.0
Q4	28	32	12.00	4	48.0	28.0
Annual	32	32	10.88	0	3.5	00.0

When quantities of inventories are used, changes in inventories at current prices are calculated by multiplying the change in quantities of inventories between the closing and opening dates of each accounting period by the average prices of the relevant period. In the example (1), the quantity change for the first quarter of year (t+1) is 3 and the average price of the product in the first quarter is 10.0, thus the changes in inventories at current prices for this quarter is 30.0 [30 = 3*10.0].

The estimates at constant prices [average prices of year (t)] are obtained by multiplying the quantity change in inventories in each quarter of year (t+1) by the average price of inventories in year t (7). Thus, for the first quarter of year (t+1) the estimates at constant prices of period (t) is 21.0 [21 = 3*7.0].

Example 2: Calculations of changes in inventories using data on book values of inventories

The example presented in this Appendix shows calculation procedures and available information to estimate changes in inventories if book values of inventories that are based on FIFO method of enterprise inventory accounting are used. Tables 2 and 3 show the data that are available and used to estimate changes in inventories. Tables 4 through 7 show the calculation steps and procedures.

Table 2. Book Values of Inventories

Year ($t+1$)	Book Values	
	Opening	Closing
Q1	1200	1500
Q2	1500	1300
Q3	1300	1600
Q4	1600	1400

It is assumed that book values of inventories are based on a FIFO inventory valuation method and that the average holding period is 2 months at any time during year ($t+1$).

Table 3. Prices Indices

Price indices (Year $t-1$=100)		
Months	Year (t)	Year ($t+1$)
January	76.3	128.1
February	79.4	133.0
March	86.5	134.6
April	92.6	141.0
May	95.7	141.0
June	99.7	139.0
July	103.8	142.3
August	104.8	145.2
September	107.9	146.0
October	112.0	147.8
November	117.0	149.1
December	124.2	152.0
Annual average	100.0	141.6

Note that the price indices refer to the product or product group included in inventories.

Table 4. Derivation of Deflators for Book Values of Inventories

	Weight	31 Dec. year (*t*)	31 March year (*t*+1)	30 June year (*t*+1)	30 Sep. year (*t*+1)	31 Dec. year (*t*+1)
Holding period of 1-2 months	0.5	117.0	133.0	141.0	145.2	149.1
Holding period of < 1 month	0.5	124.2	134.6	139.0	146.0	152.0
Deflator for book values (Year *t* = 100)	1.0	120.6	133.8	140.0	145.6	150.6

In Table 4, deflators are calculated for the opening and closing book values of inventories for each quarter of the year (*t*+1). The average holding period is usually derived in terms of months. It can be calculated by counting the number of months worth of entries (production in the case of output and purchases in the case of goods for resale and raw materials) required to make up the inventory. Numerical examples in Box (8) and (9) show how weights can be derived using enterprises' financial data under the FIFO and weighted-average-cost methods, respectively.

In Table 4, the weights under FIFO method of inventory valuation are derived on the basis of estimated holding period of two months assuming equal proportions of inventories acquired in each of the two previous months. Note that if monthly data on inventory acquisition are available, the weight of inventories acquired each month can be calculated independently.

The deflator for a book value at a specific date is derived as a weighted average of monthly price indices where the weights represent proportions of inventories acquired in each month that remain in inventories. In the example, the deflator for the opening inventories of first quarter of year (*t*+1) is 120.6, which is the weighted average of price indices of November and December of year (*t*) [117.0 and 124.2, respectively].

Table 5. Calculation of Opening and Closing Inventories at Constant Prices of year (*t*)

	31 Dec. year (*t*)	31 March year (*t*+1)	30 June year (*t*+1)	30 Sep. year (t+1)	31 Dec. year (*t*+1)
Book values of inventories	1,200.0	1,500.0	1,300.0	1,600.0	1,400.0
Deflators for book values	120.6	133.8	140.0	145.6	150.6
Values of inventories at annual average prices of (*t*)	994.9	1,121.1	928.6	1,098.9	929.9

Table 5 shows the calculation of the opening and closing inventories for each quarter at the annual average prices of year (*t*). This is obtained by deflating the reported book values by the specific deflators calculated in Table 4. In the example, the value of inventories on June 30 of

year (t+1) at annual average prices of year (t) is 928.6, which is obtained by dividing the book value of 1300.0 by the specific deflator for these inventories (140.0).

Table 6. Change in Inventories at Constant Prices (Year t)

	Opening [1]	Closing [2]	Change [3] = [2] - [1]
Q1 year t+1	994.9	1121.1	126.2
Q2 year t+1	1121.1	928.6	-192.5
Q3 year t+1	928.6	1098.9	170.3
Q4 year t+1	1098.9	929.9	-169.0
Annual	994.9	929.9	-65.0

The change in inventories at constant prices for each quarter is calculated as closing inventories at constant prices minus opening inventories at constant prices.

Table 7. Change in Inventories at Current Prices

Period	Average Price Index	Change at Constant Prices	Change at Current Prices
Q1 year t+1	131.9	126.1	166.3
Q2 year t+1	140.3	-192.5	-270.1
Q3 year t+1	144.5	170.3	246.1
Q4 year t+1	149.6	-169.0	-252.8
Annual		-65.0	-110.5

The average price index for the first quarter of year (t+1) is 131.9, which is an average of the price indices of January, February and March of year (t+1). In this example, the quarterly changes in inventories at constant prices are multiplied by the average price index of corresponding periods to derive changes in inventories at current prices. For the first quarter of year (t+1), the estimate of changes in inventories at current prices is 166.3 [166.3 = (131.9*126.1)/100].

Selected Bibliography

Bloem, Adriaan M., Paul Cotterell, and Terry Gigantes, 1996, "National Accounts in Transition Countries: Distortions and Biases," IMF Working Paper 96/130 (Washington: International Monetary Fund).

Bloem, Adriaan M., Robert J. Dippelsman, and Nils Ø. Maehle, 2001, "Quarterly National Accounts Manual: Concepts, Data Sources, and Compilation" (Washington: International Monetary Fund).

Commission of the European Communities, 2000, "Deflation of Changes in Inventories: Revised Paper," Eurostat B1/CN 441 e, paper presented at the Meeting of the Working Party on National Accounts, Luxembourg, June 5-6.

Commission of the European Communities, International Monetary Fund, Organization for Economic Cooperation and Development, United Nations, and World Bank, 1993, "System of National Accounts 1993" (New York: United Nations).

Epstain, Barry J. and Abbas A. Mirza, 1999, "Wiley IAS 99: Interpretation and Application of International Accounting Standards 1999" (New York: John Wiley and Sons).

Fiorito, Riccardo, 1991, "Inventory Accounting and Profit Evaluation," *Review of Income and Wealth*, Series 37 (4), December, pp. 433–45.

Fixler, Deenis J., and Brent R. Moulton, 2001, "Comments on the Treatment of Holding Gains and Losses in the National Accounts," STD/NA(2001)27, paper presented at the Organization for Economic Cooperation and Development Meeting of National Accounts Experts, Paris, October 9-12.

International Accounting Standards Committee (IASC), 2001, "International Accounting Standards 2001: The Full Text of All International Accounting Standards and SIC Interpretations Extant at 1 January 2001" (London: IASC).

McCarthy, Paul, 2000, "Measuring Holding Gains in Inventories," CES/AC.68/2000/18, paper presented at the Joint United Nations Economic Commission for Europe/Eurostat/Organization for Economic Cooperation and Development Meeting on National Accounts, Geneva, April 26–28.

Organization for Economic Cooperation and Development, 2001, "Measuring Capital: A Manual on the Measurement of Capital Stocks, Consumption of Fixed Capital and Capital Services" (Paris).

Peleg, Soli, and Daniel Finzi, 2000, "Measuring Inventories Under High Inflation," CES/AC.68/2000/24, paper presented at the Joint United Nations Economic Commission for Europe/Eurostat/Organization for Economic Cooperation and Development Meeting on National Accounts, Geneva, April 26–28.

United Nations, 2000, "Handbook of National Accounting: Links Between Business Accounting and National Accounting" Studies in Methods, Series F, No. 76 (New York).