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QUADERNI DEL DIPARTIMENTO
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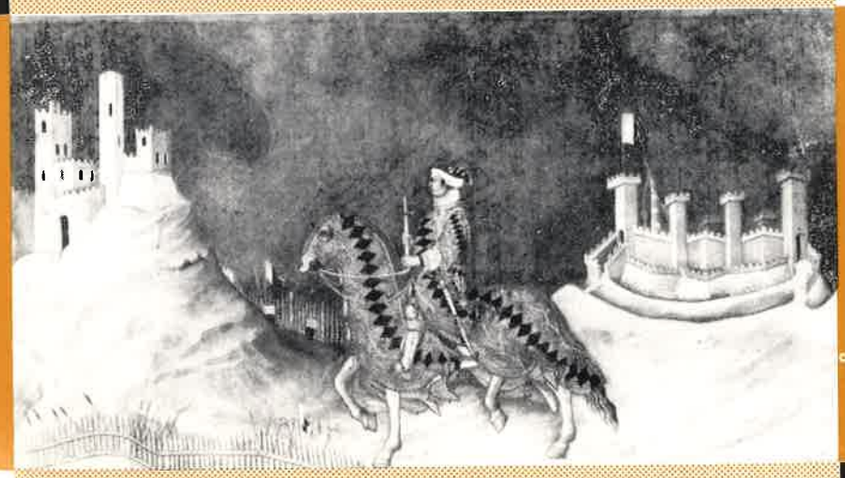
Riccardo Fiorito

INVENTORY ACCOUNTING AND PROFIT EVALUATION



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Riccardo Fiorito

INVENTORY ACCOUNTING AND PROFIT EVALUATION

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1. Introduction

The value of inventories in an inflationary environment reflects the accounting criteria adopted by firms (FIFO, LIFO, etc.) which rarely coincide with national accounts (NA). Since macroeconomic figures usually stem from collecting a large amount of self-reported microdata, both flow and stock estimates of NA inventories need to be corrected. This is so because stock appreciation does not only characterize FIFO (not frequently used) but also regards the much more popular LIFO when volumes are reduced.

Whatever accounting criteria a firm may select, it is obvious that NA statisticians observe only the reported values. The quantities have to be discovered by trying to replicate the firm's criteria. Symmetrically, the firm knows the quantity but not the value of its inventory stock which is calculated not only on the basis of its own accounting but also of its own fiscal goals.

To clarify these issues, I will illustrate FIFO, LIFO and NA methods with a simple model. I will apply them to a hypothetical, aggregate, economy to show their differences and consequences on the business cycle.

The second purpose of this article is to link the inventory evaluation with functional income distribution. This, in turn, has several implications on the meaning and estimate of taxable income.

2. Quantity relations

Let me assume that an economy produces a single storable good and buys a single, storable, intermediate product. Defining the stock at the end of period t (t= 0,1,2,..,T), let me denote the following variables in volume:

h = inventory stock
hm = raw materials stock
hf = finished goods stock
qi = inflows into the warehouse
qo = outflows from the warehouse
ip = intermediate purchases
ic = intermediate consumption
s = sales
y = output

Let me now introduce the following price indexes:

p = price index of inventory stock
pm = price index of inputs
pf = price index of sales

Let me, finally, denote with capital letters the following nominal variables:

Y = output
S = sales
H = inventory stocks
HM = raw materials stocks
HF = finished goods stocks
IP = intermediate purchases
IC = intermediate consumption
CS = cost of sales
VA = value added
W = compensation of employees
PR = gross profits

Denoting by D the first difference operator, I define inventory changes as the net difference between the inflows and the outflows of the warehouse:

(1) $Dh_t = qi_t - qo_t$

By cumulating Eq.1 I obtain two equivalent expressions for the stock level:

(2) $h_t = h_{t-1} + (qi_t - qo_t)$,

and:

(3) $h_t = h_0 + \sum_{i=1}^{t} Dh_i \equiv h_0 + (\sum_{i=1}^{t} qe_i - \sum_{i=1}^{t} qu_i)$

where $h_0 > 0$ indicates the initial volume of the stock. Note that in physical units, the stock at the end of the year must be identical to the stock at the beginning of the next year ${}_0h_t$:

(4) $h_{t-1} \equiv {}_0h_t$

Since an industrial firm's stock is composed of raw materials, intermediate products and finished goods, I link the inventory accounting with the theory of the firm, using the following relations:

(5) $y_t = s_t + Dhf_t$

(6) $ic_t = ip_t - Dhm_t$

(7) $qi_t = ip_t + y_t$

(8) $qo_t = ci_t + s_t$

in which I either assimilate, for simplicity, the intermediate product inventory to raw materials (HM) or to finished goods, depending on the stage of production. Similarly, the intermediate purchases are limited to the goods only, in this case services being irrelevant.

Eq.5 expresses the volume of production as a sum of the sales and the changes of finished goods stocks, the latter acting as a buffer between supply and demand as in production smoothing theory.

The changes in the stock of raw materials can instead be defined as the difference between supply and demand of nonlabor inputs:

(9) $Dhm_t = ip_t - ic_t$

Eq.1 then amounts to the expression:

(10) $Dh_t = (ip_t - ic_t + y_t - s_t) \equiv Dhm_t + Dhf_t$

Likewise, the overall stock will be:

(11) $h_t = hm_t + hf_t$

except for commercial units which hold finished goods only.

3. Nominal relations and accounting methods

In physical terms inventory evaluation does not present any particular problem. Problems arise, however, in nominal data because of different assumptions about the timing of either purchasing or releasing materials and products.

When inflation occurs, the purchasing costs for materials and the cost of producing finished goods can notably differ from **replacement** costs which are implicit in the NIFO (Next in-First Out) criterion when it considers the stocks as materials or products to replace at the moment in which they are available [Horngren, 1981].

Alternatively, the criterion of **historical** costs evaluates stocks according to the time and price at which they enter the warehouse, except in the

particular case in which market prices are lower than purchase costs.

Despite the fact that the replacement cost has been recommended during periods of rapid inflation also in official documents [Sandilands Report, 1974], it is not normally used as a basis for evaluation of stocks by either accountants who tend to consider it too subjective or by civil law which usually conforms, in most countries, to the criterion of lower-of-cost-or-market.

As for economists, if inventory stock evaluation according to replacement cost can be justified in the case of raw materials, this appears barely plausible in its general implications: in extreme terms they indeed amount to assuming that all intermediate purchases are consumed and that all finished goods are instantly sold. But as a matter of fact this corresponds (as in Just-In-Time) to eliminating inventory from the strategic variables of the firm and, therefore, also to making their measurement superfluous.

The alternative evaluation of stocks, based on historical costs, produces a variety of accounting criteria which depend on the different hypotheses on depletion of products. If this occurs as in the FIFO (First In-First Out) case, giving precedence to the goods which were first received, we find ourselves on the polar extreme from the replacement cost, while if we assume as in LIFO (Last In-First Out) that goods that enter last leave the warehouse first, the evaluation of the costs tends to equal that of replacement cost as the production period gets smaller.

Ignoring national differences, NA usually assume (UN-SNA, EEC-SEC etc.) that the variation of the stocks has to be evaluated at the average price of the year in

order to make the quantities consistent with price indexes.[1]

Another feature of NA evaluation consists in the fact that the values of stock at the end of the period and the corresponding value at the beginning of the new period should, even though the physical amount is the same, differ by an amount equal to the average inflation rate of the two periods. In NA the evaluation of nominal stocks at the average price of the period leads to estimates of the stocks which - as in FIFO- are inconsistent with the sum of the flows [Patterson-Stephenson, 1988]. The level of the stock obtained, say, by the sum of four quarterly data is generally different from the amount obtained annually since there is no reason why the average of the annual index should be equal to the weighted average of the corresponding quarterly (average) price indexes.

In this paper I will formalize both FIFO and LIFO criteria, neglecting HIFO which differs from LIFO only when prices are reduced, a fact that in modern economies is rather uncommon.

3.1 Nominal relations

Before discussing in detail the implications relative to accounting methods, I establish the following nominal relations:

$$(12) \quad Y_t = S_t + DHF_t$$

$$(13) \quad VA_t = Y_t - IC_t$$

$$(14) \quad IC_t = IP_t - DHM_t$$

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[1] If we calculated stocks in the presence of inflation at the prices of the current period, we would have price indexes inconsistent with those observed.

from which I obtain the value added expression in terms of the total nominal inventory changes DH ≡ DHM +DHF:

$$(15) \quad VA_t = S_t - IC_t + DH_t$$

Since value added can be defined as the sum of labor share (W) and gross profits (PR), I express the latter through the simple transformation:

$$(16) \quad PR_t = S_t - CS_t$$

in which the cost of sales (CS) can, in turn, be defined as the difference between opening stock, current costs (AI+W) and closing stock:

$$(17) \quad CS_t = [H_{t-1} + (IP_t + W_t) - H_t]$$

Combining Eqs.16 and 17 with Eqs.6 and 11, I express profits as the value of sales plus finished-goods inventory changes less the costs of production:

$$(18) \quad PR_t = S_t - (IC_t + W_t) + DHF_t$$

By applying Eq.6, gross profits are also obtained as the difference between sales plus inventory changes less the cost of purchasing labor and intermediate inputs:

$$(19) \quad PR_t = S_t - (IP_t + W_t) + DH_t$$

Hence we easily obtain an expression for the cost of sales:

(20) $CS_t = IC_t + W_t - DHF_t \equiv IP_t + W_t - DH_t$

In Eq.18 it should be noted that profits are increased by positive variations of finished-goods stocks that can be interpreted as a potential for future sales wich do not require extra-costs.

This mechanism is most relevant to an understanding of how to deflate the finished-goods stock regardless of the accounting method. If, in fact, the stock of finished products is considered a component - even if not synchronized - of sales, the implicit price deflator should be the same as the sales deflator, it being impossible that a dollar of stock corresponds to a different quantity of a dollar of sales [West, 1983] as is implicit in the Department of Commerce method in which finished-goods stock is deflated by a cost index [Herman-Donahue-Hinrichs,1977; Hinrichs-Heckman, 1981].

This same objection can be raised for the accounting practice or civil law tradition which in many countries prescribes the evaluation of the stocks of finished goods at the lower-of-cost-or-market and, therefore, in most cases, at the cost of production.

3.2 Accounting methods

3.21 FIFO

FIFO accounting assumes that the goods that have been purchased or produced first are utilized or sold first. In an inflationary environment this implies an appreciation of the stock since each outflow leaves a higher number of recent products or materials in the warehouse. The aggregate equation for the stock can be stated as:

(21) $H_t = p_{t-1}h_{t-1} + (p_t qi_t - p_{t-1} qo_t)$

where p is the weighted average of raw material and finished good prices. Assuming that the price of inputs (pm) applies equally to intermediate purchases or consumption, the expression for the raw material stock becomes:

(22) $HM_t = pm_{t-1}hm_{t-1} + (pm_t ip_t - pm_{t-1} ic_t)$

Similarly, for finished-goods stocks we have:

(23) $HF_t = pf_{t-1}hf_{t-1} + (pf_t y_t - pf_{t-1} s_t)$

where sales and output are assumed to have the same price (pf).

In FIFO the remaining stock appreciates because of inflation and then exceeds its previously estimated value (H_{t-1}):

(24) $H_{t-1} < p_{t-1}h_{t-1}$

Setting, in fact, $h_{t-1} = h_0 + \sum_{i=1}^{t-1} Dh_i$, Eq.21 can be rewritten as:

(25) $H_t = p_{t-1}(h_0 + \sum_{i=1}^{t-1} Dh_i) + [p_t qi_t - p_{t-1} qo_t]$

where the initial stock (h_0) appreciates just as a result of inflation. In fact when $p_{t-1} > p_0$ the stock increases even though the quantities do not change. Inserting Eq.20 in Eq.21, noting that $pm_t ip_t \equiv IP_t$, $pm_t ic_t \equiv IC_t$, etc., defining $pm_t ic_t \equiv IC^0_t$, $pf_t s_t \equiv S^0$, one can see that $IC^0_t < IC_t$ if $pm_t > pm_{t-1}$ and also that $S^0_t < S_t$ if $pf_t > pf_{t-1}$.

Combining these expressions I obtain an expression for FIFO profits (PRF) that exceeds the amount implied by Eq.18 and 19. This appears clearly in:

$$(26)\quad PRF_t = PR_t + (p_{t-1}h_{t-1} - H_{t-1}) + (S_t - S^{\circ}_t) + (IC_t - IC^{\circ}_t)$$

where the terms in parentheses denote inventory appreciation, increase in the value of sales and of intermediate consumption, respectively.

What should be noted in Eq.26 is that FIFO may account for gross profits even when PR=0, the other terms on the right hand side being positive as a result of inflation. FIFO accounting implies then capital gains on the stock at hand:

$$(27)\quad CG_t = PR_t - PRF_t$$

that are not found in the fix-price case or when LIFO is used instead. This fact has produced a wide discussion on the meaning of income [Parker-Harcourt, 1969] and, thus , of taxable income [Godley-Wood, 1975; Coutts, 1978; Kennedy, 1978; Shoven-Bulow, 1975] that goes beyond the scope of this article and for which I refer the reader to the specialized literature.

3.22 LIFO

In dealing with LIFO accounting it is necessary to distinguish between null or positive inventory changes on one side and decumulation of the stock on the other. In the first case it is possible to match current demand for finished goods or inputs with the last layer of inventory, i.e. without having the necessity of reducing the level of the stock. In the second case the firm will actually utilize LIFO accounting just for

that part of its demand that can be satisfied by the last inflow of materials or products. The remaining, unsatisfied, demand will be matched by drawing inventories from previous layers of the existing stock.

The first case can be formalized as:

$$(28)\quad H_t = H_{t-1} + p_t(qi_t - qo_t),\ qi_t \geq qo_t$$

while the second, in which $qi_t < qo_t$, corresponds to:

$$(29)\quad H_t = H_{t-1} - [\sum_{i=1}^{k} w_i p_{t-i}(qi_{t-i} - qo_{t-i})],\quad qi > qo,\ \forall i$$

where:

$$(30)\quad \alpha_t qi_t = qo_t \quad ,\quad 0 \leq \alpha_t < 1$$

is the part of inventory outflows that it is possible to provide through current inflows. The residual part - which corresponds to an excess demand for current stocks - appears in brackets in Eq.29 and is obtained by a sequence of withdrawals, weighted according to the time of entering the warehouse and priced conformably for those lots which have not been exhausted. The selected weights are:

$$(31)\quad w_i = [(qi_{t-i} - qo_{t-i})/qo_t(1 - \alpha_t)],\quad \sum_{i=1}^{k} w_i = 1$$

Since manufacturing firms hold both stocks of materials and finished-goods, the rise (reduction) of the first component may coexist with the reduction (rise) of the second. Thus it becomes necessary to consider four different cases. The first deals with the raw-materials stock when purchases are equal to or higher than intermediate consumption:

(32) $HM_t = HM_{t-1} + pm_t(ip_t - ic_t),\ ip_t \geq ic_t$

When the opposite happens we have:

(33) $HM_t = HM_{t-1} - [\sum_{i=1}^{k} w_i\ pm_{t-i}(ip_{t-i} - ic_{t-i})]$

where:

(34) $\alpha_t ic_t = ip_t, \qquad 0 \leq \alpha_t < 1$

is the intermediate consumption requirement matched by the last purchases. In Eq.33 we can see in brackets the residual part of the raw-materials stock which has been accumulated before, without being utilized as an input. The relevant prices are determined according to the following weights:

(35) $w_i = [(ip_{t-i} - ic_{t-i})/ic_t(1 - \alpha_t)],\ ip > ic\ ,\ \forall i$

When changes of finished-goods stocks are positive or nil we have:

(36) $HF_t = HF_{t-1} + pf_t(y_t - s_t),\ y_t \geq s_t$

while for negative changes:

(37) $HF_t = HF_{t-1} - [\sum_{i=1}^{k} w_i pf_{t-i}(y_{t-i} - s_{t-i})],\ y_{t-i} \geq s_{t-i}, -\forall i$

Likewise:

(38) $\alpha_t s_t = y_t$

denotes that portion of sales which equals current output. Thus, the excess demand will be cleared by decumulating finished goods stocks. The cost of drawing previous stocks will be evaluated according to the following weights:

39) $w_i = [(y_{t-i} - s_{t-i})/s_t(1-\alpha_t)],\ \sum_{i=1}^{k} w_i = 1,\ y_{t-i} > s_{t-i},\ \forall i$

It is easy to show through Eqs.18, 19 and 29 that in LIFO a rising or stable level of inventories does not imply an appreciation of the stock. This also means that LIFO, unlike FIFO, does not reveal any profit resulting from inflation [Tobin, 1988], capital gains being signalled by this method solely when stock volume is reduced.

In fact, by computing cost of sales we obtain an expression for capital gains which is similar to FIFO Eqs.26 and 27:

(40) $CG_t = PR_t - PRLF_t = (S_t - \bar{S}_t) - (IP_t - \bar{IP}_t)$

where PRLF denotes profits due to stock appreciation and $\bar{S}$ and $\bar{IP}$ denote the corresponding flow component.

4. A simulation experiment

4.1 Microeconomic assumptions and data generation

To generate a consistent set of data, I will utilize a simple microeconomic model where the economy produces a single storable good according to the following technology:

(41) $y_t = A + b*ic_t = {}_t s^e_{t-1}\ , \quad b>0$

in which production is obtained, in the short run, by utilizing intermediate inputs (ic) and a constant amount of labor (n) which is assumed to be proportional to A, a scale factor:

(42) $A \equiv K + c*n$, $\quad c>0$

In Eq.41 output is planned to equal the volume of sales that the agents, at the end of period t-1, predict for period t ($_ts^e_{t-1}$). Assuming that goods and factors are sold in competitive markets, sales, prices and wages can be considered exogenous. The requirement for intermediate consumption will be then:

(43) $ic_t = \alpha + \beta *\, _ts^e_{t-1}$, $\quad \alpha \equiv -b^{-1}A$, $\beta \equiv b^{-1}$

Usually, intermediate purchases are not utilized in the same period in which they are available so as to anticipate possible rises in costs and to ensure continuity of production. It is then reasonable to assume that also intermediate purchases depend on expected sales. However, this expectation should be formed earlier than the output plans are originated because of the delivery lags and of the fact that production takes time.

Assuming that both sources of lags amount to one period, intermediate purchases are expressed in terms of sales prediction for time t which has been formed two periods before:

(44) $ip_t = \alpha + \beta *\, _ts^e_{t-2}$

Combining Eqs.43, 44 and 9, we can see how raw-

materials inventory changes are proportional to the revision of expectations occurring within these two forecasting periods:

(45) $Dhm_t = \beta(_ts^e_{t-2} - \, _ts^e_{t-1})$

while finished-goods inventory changes can be interpreted, bearing in mind Eqs.5 and 41, as a buffer between supply and demand for commodities:

(46) $Dhf_t = \delta(_ts^e_{t-1} - s_t)$, $\quad (\delta=1)$

that will be the stronger the less flexible are production plans.[a]

To produce a numerical example, it is necessary to determine the value of relevant parameters and exogenous variables, under the constraint that both inputs and output are nonnegative and that the share of inputs will be positive but less than 1. Both requirements are satisfied if $_ts^e_{t-1} > A$ and $b>1-A/Y$.

The selected values are: A=230, n=100, b=0.6; the volume of sales is arbitrary but has been chosen so as to mimic the cyclical behavior, on an annual basis, of the Italian economy since 1970. The volume of sales predicted one step ahead ($_ts^e_{t-1}$) has been obtained by an AR(2), while the sales predicted two steps ahead ($_ts^e_{t-2}$) have been obtained by regressing actual sales on their lagged value two-periods before, this being

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[a] There is no need to hold finished-goods stocks if supply is perfectly flexible ($\delta=0$). Conversely when $\delta=1$, production plans are perfectly inflexible [Lovell, 1974] since markets clear through inventory adjustment only.

the information set available at that time. Finally, the initial stock of both finished goods and raw materials have been set equal to 100.

For the sake of realism, I have used as input (pm) and output prices (pf) the corresponding quarterly indexes calculated by the Central Statistical Office (ISTAT) for Italy's manufacturing.[3]

In order to assess value added and the role played by inventory accounting in profit measurement, I have assumed that nominal wage and price of output have the same index or else that real (product) wage is constant over the simulation period. Of course, this assumption will affect our profit estimates but in a way which is independent of inventory accounting and which may then appear irrelevant for our purposes.

4.2 Results

Combining the accounting model (1)-(11) with the microeconomic assumptions (41)-(46), the balance of physical output consistent with the selected parameters is displayed in Table 1.

To mention a few results, the stock/sales ratio in volume, after an initial rise, gradually tends to become smaller. Raw-materials stocks are the most volatile inventory component. They accumulate by a process of revising expectations (Eq.45) that is more erratic than the one-period ahead prediction error which explains in Eq.46 finished goods inventory changes.

Output and sales grow at about the same rate (1.3%) and with about the same variance. Altogether, the quantity variables displayed in Table 1 seem to closely

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[3]Beginning and end-of-period data are obtained as the arithmetic mean of the two contiguous quarters.

mimic the cyclical behavior of a real economy and constitute a reasonable starting point to shape nominal variables. These (see Tables 2 and 3) are, obviously, obtained by multiplying volumes by the historical (1970-88) input and output price indexes. Since nominal evaluation of inventory investment implies choosing some accounting method, we shall compare FIFO, LIFO and NA data to assess how inventory accounting affects the estimation of gross profits.

Another result of our simulations is the possibility of obtaining from exogenous sales - given Eq.5 - a measure of the output implied by FIFO, LIFO and NA accounting. Deflating this level by its price index (pf), we obtain the criterion leading to the best estimate of physical output, whose "true" value we known from Table 1.

Generally speaking, all results show a close similarity between LIFO and NA, FIFO simulations being quite different from the others. This is also true for the stock/sales ratio (see Tables 1 and 3) which is actually better estimated by FIFO than by LIFO and NA. In fact LIFO and FIFO measures, as they ignore or underestimate capital gains, impart a downward bias to the nominal stock/sales ratio which is amplified over time by the persistence of inflation. Therefore this ratio should not be considered an indicator of physical stock that firms desire to hold for a given volume of sales, unless capital gains corrections are introduced. As Table 5 shows, the average level of FIFO stocks is about three times larger than the corresponding LIFO figure which, in turn, exceeds the estimated NA value.

Another difference in stock measurement is that- while physical inventory (see Table 1) is always positive - NA raw-materials stock has a zero value in

periods 11 and 12 when nominal releases exceed the value of the remaining stock.

Similarly, the average level of inventory changes is much higher in FIFO (see Table 5) than in other cases. This makes it inappropriate to compare variances- which are not scale-free - to assess differences in volatility implied by accounting methods. In fact, if we measure the latter by scaling the standard deviation of each variable by its arithmetic mean (i.e. by calculating Pearson's coefficient of variation), we can see that the variability of FIFO is smaller than that of LIFO and even more than that of NA. Considering that in this example data in levels do not present large differences in volatility, the idea is confirmed that the bigger FIFO scale reflects an inflationary trend which, in turn, attenuates cyclical fluctuations in inventory stock.

As shown in Table 4, inventory changes in LIFO and NA are remarkably similar when i) changes are positive and when ii) a mild inflation occurs. This happens in one case because LIFO and NA do no allow for stock appreciation unless inventory is reduced and in the other because if the annual inflation rate is low, the half-period price cannot be too different from the end-of-period index.

Inventory changes so obtained lead to an estimation of profits that fully conforms with theoretical expectations in Eqs.26 and 27. In fact, FIFO profits - with the exception of period 17 when prices of raw materials fall - always exceed LIFO estimates because of the different definitions of the cost of sales which have been discussed in Section 3. Thus in FIFO estimates the ratio of profits to sales is, on the average, about 30% while in LIFO and in NA the same figure is 14% and 13%

Table 1 - Inventory, output and sales in volume

Period	ip	ic	dhm	hm	y	s	dhf	dh	hf	h	h/s
0	--	--	--	100.0	100.0	--	--	--	100.0	200.0	--
1	133.1	130.5	2.6	102.6	308.4	300.0	8.4	11.0	108.4	211.0	0.70
2	142.3	128.5	13.8	116.4	307.2	305.0	2.2	16.0	110.6	227.0	0.74
3	140.9	136.5	4.4	120.8	312.0	308.0	4.0	8.4	114.6	235.4	0.76
4	148.0	141.1	6.9	127.7	314.8	320.0	-5.2	1.7	109.4	237.1	0.74
5	152.3	160.1	-7.8	119.9	326.2	332.0	-5.8	-13.6	103.6	223.5	0.67
6	169.5	178.8	-9.5	110.4	337.4	317.0	20.4	10.9	124.0	234.4	0.74
7	186.3	154.2	32.1	142.5	322.7	325.0	-2.3	29.8	121.7	264.2	0.81
8	165.0	167.7	-2.7	139.8	330.8	334.0	-3.2	-5.9	118.5	258.3	0.77
9	176.3	181.7	-5.4	134.4	339.2	340.0	-0.8	-6.2	117.7	252.1	0.74
10	189.1	190.9	-1.8	132.6	344.7	367.0	-22.3	-24.1	95.4	228.0	0.62
11	197.6	233.8	-36.2	96.4	370.4	378.0	-7.6	-43.8	87.8	184.2	0.49
12	235.9	250.2	-14.3	82.1	380.2	370.0	10.2	-4.1	98.0	180.1	0.49
13	251.5	236.8	14.7	96.8	372.3	365.0	7.3	22.0	105.3	202.1	0.55
14	240.2	229.2	11.0	107.8	367.7	353.0	14.7	25.7	120.0	227.8	0.65
15	233.1	210.3	22.8	130.6	356.3	368.0	-11.7	11.1	108.3	238.9	0.65
16	216.1	234.8	-18.7	111.9	371.0	371.0	0.0	-18.7	108.3	220.2	0.59
17	237.3	238.9	-1.6	110.3	373.5	377.0	-3.5	-5.1	104.8	215.1	0.57
18	241.6	248.4	-6.8	103.5	379.2	384.0	-4.8	-11.6	100.0	203.5	0.53

Legenda:
ip = Intermediate purchases
ic = Intermediate consumption
dhm = Inventory changes in raw-materials and intermediate products
hm = Raw-materials and intermediate product inventory stock
y = Output
s = Sales
Dhf = Inventory changes in finished goods
Dh = Total inventory changes
hf = Finished goods inventory stock
h = Total inventory stock
h/s = Stocks/Sales ratio

Table 2 - Production, intermediate purchases and sales at current prices

Period	$_{o}$pm	pm	$_{o}$pf	pf	IP	S
1	98.0	102.7	97.1	103.4	137	310
2	102.7	106.3	103.4	107.7	151	328
3	106.3	114.3	107.7	117.3	161	361
4	114.3	153.1	117.3	147.2	227	471
5	153.1	211.0	147.2	196.4	321	652
6	211.0	224.7	196.4	215.5	380	683
7	224.7	282.7	215.5	267.3	527	869
8	282.7	309.4	267.3	297.4	511	993
9	309.4	341.3	297.4	333.3	602	1133
10	341.3	447.5	333.3	417.0	846	1530
11	447.5	562.6	417.0	502.6	1112	1900
12	562.6	695.4	502.6	608.7	1640	2252
13	695.4	759.8	608.7	685.0	1911	2500
14	759.8	835.4	685.0	761.5	2006	2688
15	835.4	933.3	761.5	842.9	2175	3102
16	933.3	908.1	842.9	864.0	1962	3205
17	908.1	790.6	864.0	839.8	1876	3166
18	790.6	836.6	839.8	871.5	2021	3347

Legenda: $_{o}$pm = Input prices at the beginning of period
pm = Input prices at the end of period
$_{o}$pf = Output prices at the beginning of period
pf = Output prices at the end of period
IP = Intermediate purchases at current prices
S = Sales at current prices

respectively.

A final, but not minor, result of this study deals with the ability of each method to obtain an accurate estimate of physical output. This is indeed relevant for business cycle analysis since inventory changes are a small but highly volatile conponent of demand which may affect to a large extent [De Leeuw, 1982] the short-run performance of the economy. The more this is true, the more it is necessary to have a methodology to disentangle spurious cycles induced by price changes and actual changes in inventory which are transmitted to real GNP fluctuations.

From Tables 7 and 8 we can see how NA estimates are still the best criterion for evaluating physical output and, implicitly, real GNP. However, if we also include output variance in our comparison, it should be noted that NA smooth out the cyclical pattern more than LIFO, a fact which is not surprising because averaging prices is indeed a moving average filter.

Looking at levels, FIFO overestimates output mean by more than 10% and introduces in differences spurious cycles that are barely correlated (.103) with true observations. Conversely, LIFO estimates are much more accurate in predicting levels and changes of output. In particular - as far as the mean is concerned - they are just slightly less reliable than NA estimates. In terms of variances, both LIFO and NA underestimates the true parameter by about 10%, while FIFO still appears the worst criterion because of its inability to isolate price from quantity changes.

Table 3 - Nominal inventory stock in FIFO, LIFO and NA

Period	FIFO				LIFO				NA			
	HM	HF	H	H/S	HM	HF	H	H/S	HM	HF	H	H/S
1	106.8	124.7	231.5	.75	102.7	108.7	211.4	.68	102.6	108.4	211.0	.68
2	124.7	127.6	252.3	.77	117.4	110.1	227.5	.69	117.1	110.7	227.8	.69
3	139.8	153.5	293.3	.81	122.4	114.8	237.2	.66	121.9	115.2	237.1	.66
4	203.5	222.5	426.0	.90	133.0	108.9	241.9	.51	131.1	108.3	239.4	.51
5	271.7	313.1	584.8	.90	121.4	102.9	224.3	.34	116.8	98.4	215.2	.33
6	256.2	308.1	564.3	.83	111.0	146.8	257.8	.38	96.1	140.4	236.5	.35
7	428.2	429.5	857.7	.99	201.7	141.9	343.6	.39	177.5	134.8	312.3	.36
8	439.2	416.3	855.5	.86	194.1	135.0	329.1	.33	169.5	125.7	295.2	.30
9	472.1	471.7	943.8	.83	178.8	133.2	312.0	.27	152.0	123.1	275.1	.24
10	653.5	606.4	1259.9	.82	173.8	94.5	268.3	.17	145.0	39.4	184.4	.12
11	659.0	683.3	1342.3	.71	96.4	86.9	183.3	.10	0.0	4.6	4.6	.00
12	775.8	896.2	1672.0	.74	82.1	149.0	231.1	.10	0.0	61.5	61.5	.03
13	835.6	925.0	1760.6	.70	193.8	199.0	392.8	.16	106.7	108.4	215.1	.09
14	1000.8	1103.2	2104.0	.78	285.7	310.9	596.6	.22	194.0	214.6	408.6	.15
15	1319.6	1114.7	2434.3	.78	498.5	221.8	720.3	.23	395.8	120.8	516.6	.17
16	989.9	991.4	1981.3	.62	324.0	221.8	545.8	.17	223.2	121.1	344.3	.11
17	723.0	815.3	1538.3	.49	309.0	195.6	504.6	.16	209.8	91.3	301.1	.10
18	929.8	960.0	1889.8	.50	249.8	162.7	412.5	.12	154.7	50.0	204.7	.06

Legenda: HM = Inventory stock of raw-materials and intermediate products at current prices
HF = Inventory stock of finished goods at current prices
H = Total inventory stock at current prices
H/S = Stock/sales ratio at current prices

Table 4 - Inventory changes at current prices: FIFO, LIFO and NA

Period	FIFO			LIFO			NA		
	DHM	DHF	DH	DHM	DHF	DH	DHM	DHF	DH
1	8.8	27.6	36.4	2.7	8.7	11.4	2.6	8.4	11.0
2	19.3	15.5	34.8	14.7	1.4	16.1	14.5	2.3	16.8
3	15.9	34.3	50.2	5.0	4.7	9.7	4.8	4.5	9.3
4	65.3	88.0	153.3	10.6	-5.9	4.7	9.2	-6.9	2.3
5	76.1	152.0	228.1	-11.6	-6.0	-17.6	-14.3	-9.9	-24.2
6	3.1	104.5	107.6	-10.4	43.9	33.5	-20.7	42.0	21.3
7	180.1	162.1	342.2	90.7	-4.9	85.8	81.4	-5.6	75.8
8	36.4	90.9	127.3	-7.6	-6.9	-14.5	-8.0	-9.1	-17.1
9	39.6	119.3	158.9	-15.3	-1.8	-17.1	-17.5	-2.6	-20.1
10	194.7	214.1	408.9	-5.0	-38.7	-43.7	-7.0	-83.7	-90.7
11	65.5	285.6	351.1	-77.4	-7.6	-85.0	-182.7	-34.8	-217.5
12	233.2	454.9	688.2	-14.3	62.1	47.8	-89.5	56.9	-32.6
13	264.0	328.2	592.2	111.7	50.0	161.7	106.7	46.9	153.6
14	264.8	381.8	646.6	91.9	111.9	203.8	87.3	106.2	193.5
15	418.8	200.9	619.8	212.8	-89.1	123.7	201.8	-93.8	108.0
16	-229.4	78.6	-150.8	-174.5	0.0	-174.5	-172.6	0.3	-172.3
17	-293.2	-120.6	-413.8	-15.0	26.2	-41.2	-13.4	-29.8	-43.2
18	57.5	79.7	137.2	-59.2	-32.9	-92.1	-55.1	-41.3	-96.4

Legenda: DHM = Raw-materials and intermediate-products inventory changes at current prices
DHF = Finished-goods inventory changes at current prices
DH = Inventory changes at current prices.

Table 5 - Mean, variance and coefficient of variation of nominal inventory stock

	Levels			Changes		
	FIFO	LIFO	NA	FIFO	LIFO	NA
mean	1166	347	249	228	12	-7
variance	495490	23480	13017	84623	8372	10424
cv	0.60	0.44	0.46	1.28	7.6	14.6

Legenda: cv = √variance/mean

Table 6 - Inventory and profit evaluation at current prices

Period	Sales	Intermed. purchases	Cost of labor	Profits		
				FIFO	LIFO	NA
1	310	137	103	106	81	81
2	328	151	108	104	86	86
3	361	161	117	133	93	92
4	471	227	147	251	102	100
5	652	321	196	362	117	110
6	683	380	215	195	121	109
7	869	527	267	417	161	151
8	993	511	297	313	171	168
9	1133	602	333	357	181	178
10	1530	846	417	676	223	176
11	1900	1112	503	636	200	68
12	2252	1641	609	691	51	-30
13	2500	1911	685	496	66	58
14	2688	2006	761	567	124	114
15	3102	2175	843	703	207	192
16	3205	1962	864	228	205	207
17	3166	1876	840	36	409	407
18	3347	2021	871	591	362	357

Table 7 - True and estimated output % changes

Period	True	NA	LIFO	FIFO
1	-0.4	-0.3	-0.7	-2.2
2	1.6	1.5	1.9	5.6
3	0.9	1.1	1.3	12.6
4	3.6	3.7	4.1	7.8
5	3.4	2.9	2.6	-10.7
6	-4.4	-4.1	-4.2	5.5
7	2.5	2.5	2.6	-5.5
8	2.5	2.5	2.3	3.1
9	1.6	2.3	5.4	11.3
10	7.5	7.0	5.2	3.9
11	2.6	2.2	1.0	2.3
12	-2.1	-2.0	-2.1	-7.1
13	-1.2	-1.3	-1.2	-2.4
14	-3.1	-2.7	-2.8	-2.8
15	4.1	4.0	3.8	-3.0
16	0.7	0.7	0.8	-4.6
17	1.5	1.6	1.7	8.4
mean	1.19	1.19	1.20	1.23
var.	7.97	7.02	7.18	42.81

Table 8 - Correlation matrix for actual and estimated output

LEV. \ DIFF.	TRUE	NA	LIFO	FIFO
TRUE	1.000	0.996	0.909	0.103
NA	0.999	1.000	0.938	0.157
LIFO	0.992	0.995	1.000	0.279
FIFO	0.676	0.684	0.719	1.000

(*) Entries above the principal diagonal are correlation coefficients for % differences. Entries below are correlation coefficients for levels.

5. Conclusions

Inventory changes are a major source or indicator of the business cycle. This variable, however, is one of the most difficult to measure because of inflation and its effects on stock evaluation. This problem cannot be confined to short-run diagnosis alone since it also involves a number of fiscal and distributional issues. Since inflation is much lower now than it used to be a decade ago, it might seem unimportant to deal with such an issue. This would be a rather superficial conclusion given that stocks are held to perpetuate wealth and, indeed, do perpetuate inflation for a long period by imparting random shocks to income distribution.

One reason that makes it normally difficult to estimate real inventory changes for the national economy is that firms measure their stocks according to a variety of methods that usually differ from those of NA. This would not per se be a serious problem if a link between microeconomic theory, NA and inventory accounting were fully developed. This is not the case. This paper constitutes a first effort in this direction, given our aim of formalizing and comparing FIFO, LIFO and NA methods in a simple but, hopefully, realistic framework. These criteria are then applied to a stylized economy where inventory adjustment occurs, its prices replicating the inflation pattern of Italy since 1970. Of course, this method can be easily applied for other countries but the main results would not, in my opinion, notably change because of its theoretical structure and given the increasing integration among most industrialized economies.

My principal findings are:

i) Current ratios between stocks and sales have little to do (with the possible exception of FIFO) with corresponding measures of stock/sales ratios in volume. Persistent inflation causes a strong downwards bias in the nominal ratio which is not reliable as a cyclical indicator.

ii) Among the above-mentioned criteria, only LIFO is temporally consistent since sums of flows equal the estimated stock. This does not happen with FIFO which implies an appreciation of the stocks when inflation occurs, nor does it happen with NA whose measure of nominal inventory is not independent of periodicity.

iii) It is hard to decide if the extraprofits that FIFO accounts for, are instead hidden by LIFO, being a form of capital gains bound to disappear when the firm faces higher costs to replace its stock. This point has some logic as far as raw materials are concerned but is less convincing in the case of finished-goods outflows which are sales priced as a mark-up on costs.

iv) NA provides an estimate of gross profits which is not only more conservative than that of FIFO but also than that of LIFO.

v) NA appears the best criterion to estimate output in physical terms. LIFO ranks second, being still fairly reliable and FIFO appears to be very inadequate in everything but the stock/sales ratio.

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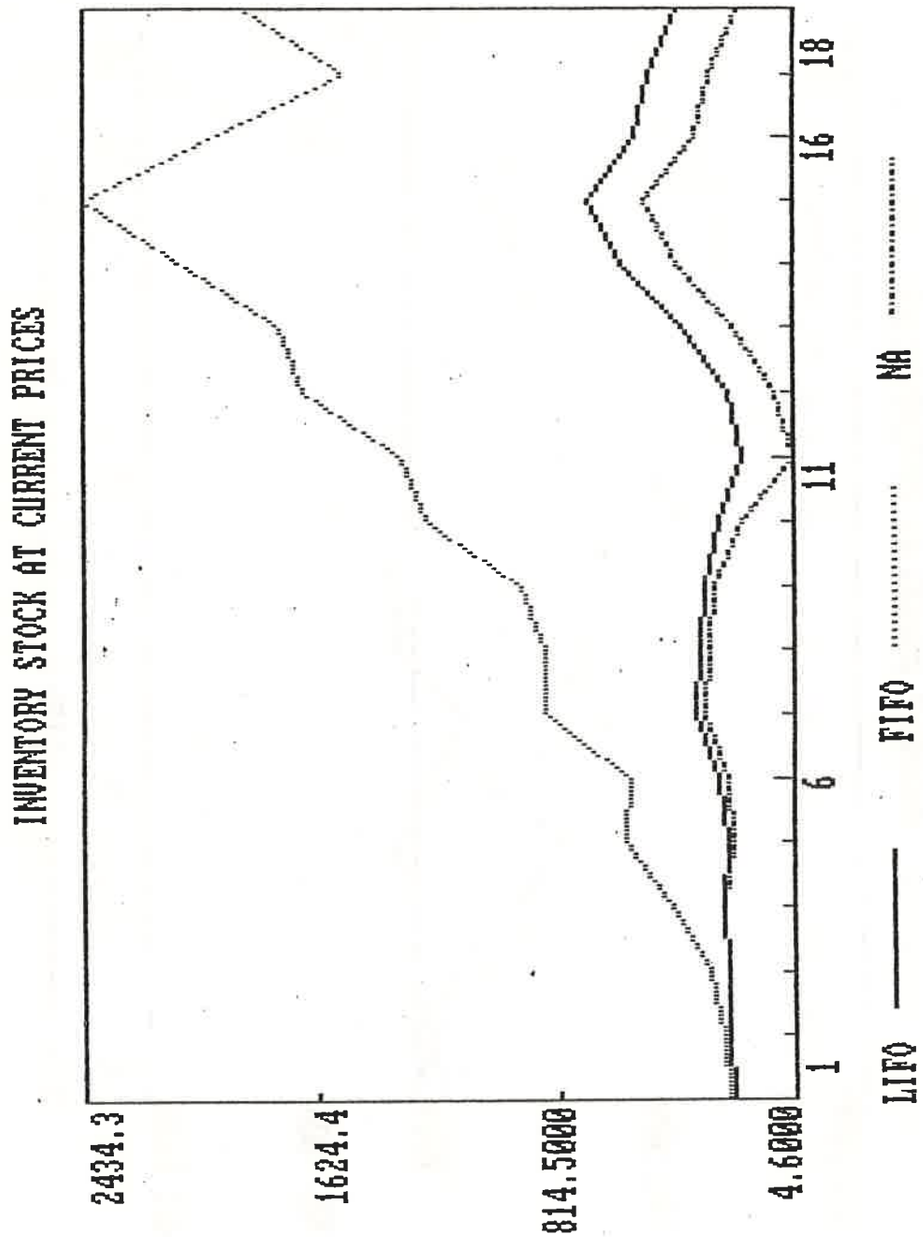
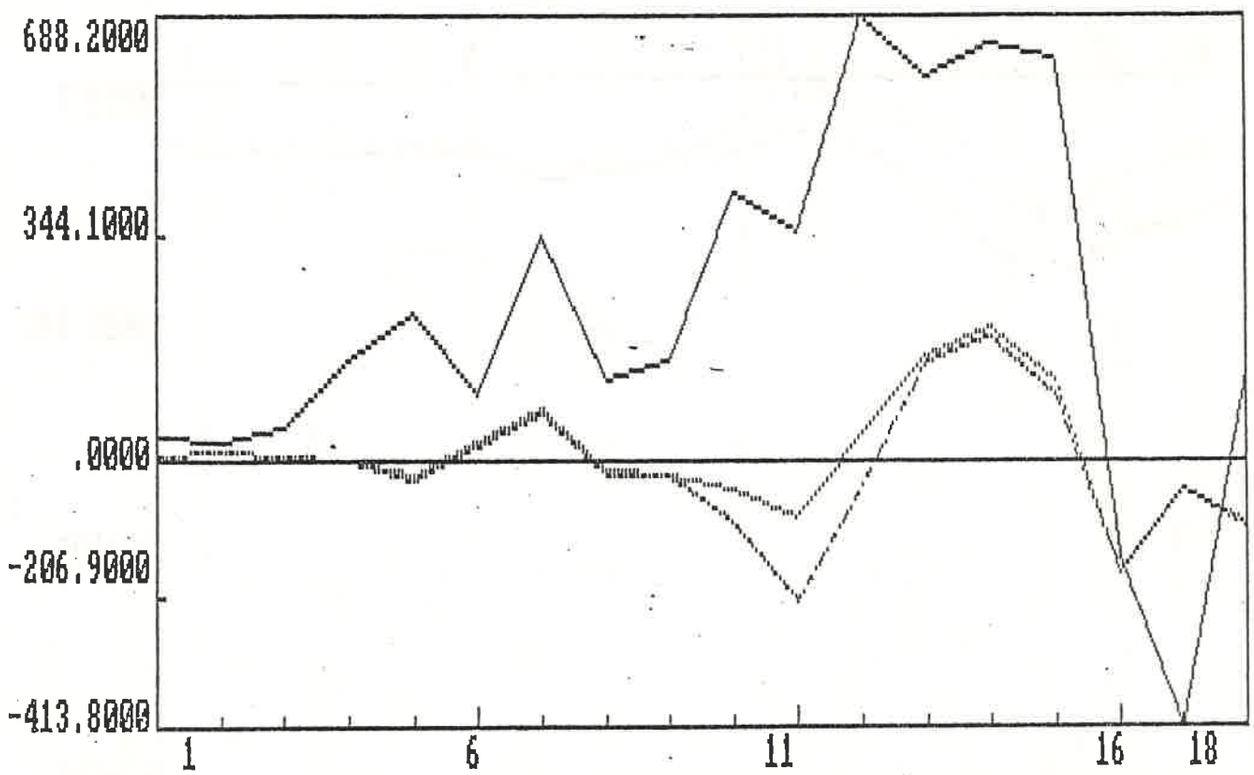
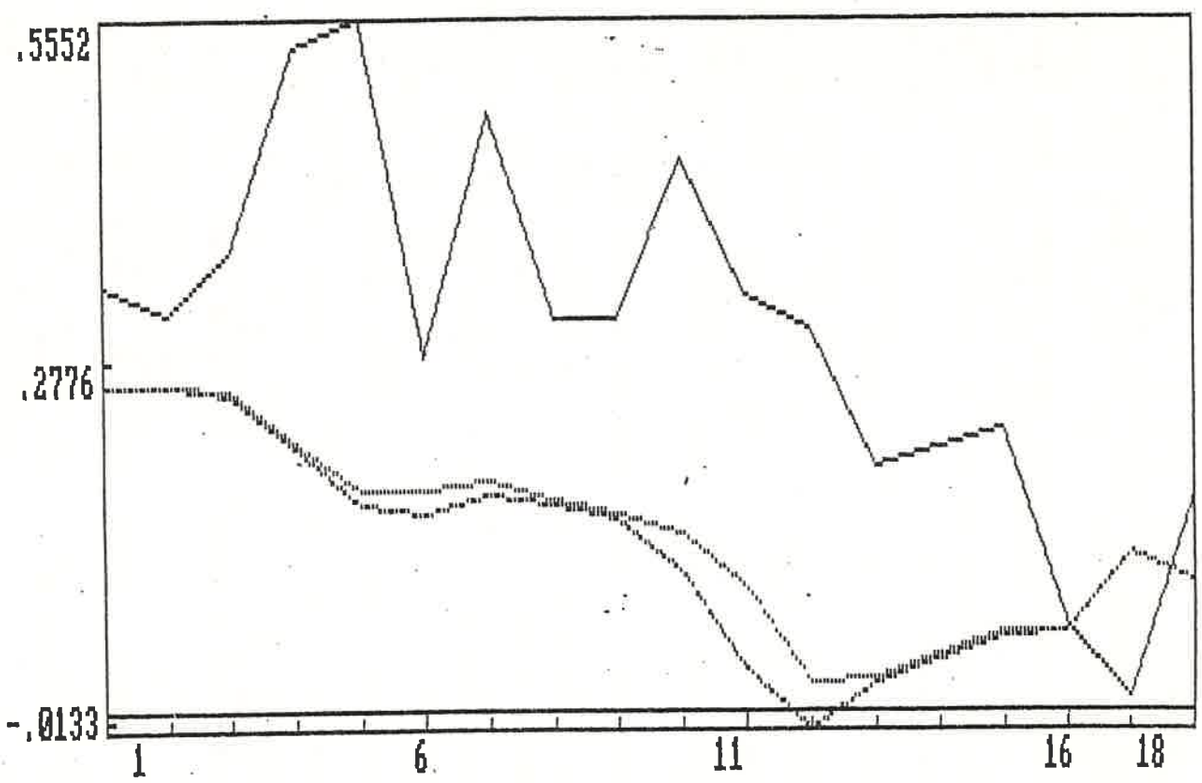


INVENTORY CHANGES AT CURRENT PRICES



FIFO ——— LIFO ..... NA .....

PROFIT/SALES RATIOS AT CURRENT PRICES



FIFO ——— LIFO ..... NA .....

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