Value of Physical Change in Farm Inventories: How Does One Reconcile Annual and Subannual Estimates?

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Background of the Issue in Canada

For Statistics Canada, there has been a substantial difference in the calculation of the value of physical change (VPC) of farm inventories by different divisions within the agency at current prices. Historically, three divisions have used a single annual price to calculate the annual VPC in inventories, while one division has used different prices to measure the VPC for each quarter, with the annual VPC calculated simply as the sum of the quarterly estimates. More specifically, Agriculture Division has used the annual approach to estimate VPC as a component of agricultural value added, Input-Output Division has used the same approach in its own calculations of gross output and value added for the Input-Output Tables, while the Industry Measures and Analysis Division has necessarily used the same approach, since the Input-Output estimates of gross output and value added at current prices are its benchmarks, from which it calculates gross output and value added in volume terms.

Until this year, only Income and Expenditure Accounts Division, which is responsible for quarterly measures of gross domestic expenditure, favoured the sum-of-quarters approach in its estimates of farm inventories, which is one of two components of the aggregate business investment in inventories, the other being (obviously) non-farm inventories. In this approach, quarterly VPC is valued at current quarter prices and the annual VPC is simply the sum of the quarterly estimates.

This difference in approach is primarily an issue relating to current price measures, since even IEAD agrees that the annual base year price used to calculate volume measures of a Laspeyres type must be calculated as some average of quarterly prices themselves, and cannot be calculated implictly from the annual VPC at current prices and the change in inventories measured in tonnes or some other physical unit of measure. However, the choice of approach does have implications for System of National Accounts price and volume estimates, especially for industry value added, as will be discussed later.

In all probability, of all the official national accounting agencies in the world, only the Canadian System of National Accounts (hereafter CSNA) has ever published two quite different measures of farm VPC at current prices. The differences between the two methods are not trivial, even at the national level. Moreover, GDP is calculated annually on a provincial basis using both the expenditure and value added approaches. For a small province with a large agriculture sector like Saskatchewan or Prince Edward Island, the discrepancy between the two is often more important in value than many other individual components of GDP.

To some extent, this has been a problem, creating an important discrepancy between the value added and sum-of-expenditures measures of gross domestic product, which, as simple textbook examples show, should be equal. At the same time, it is one of those problems that is nice to have, since it only exists because of the good quality and fine detail of the underlying Canadian industrial statistics. A 1996 OECD document found that half of the 18 countries surveyed had no independent estimates of VPC, lacking the information to do so. Other countries that do have independent estimates of inventory change may adopt the annual approach as much out of necessity as conviction, since they simply lack the detailed quarterly information to use the sum-of-quarters approach. Even the United States Bureau of Economic Analysis (hereafter BEA) has essentially adopted the annual approach by default, since for the most part it lacks the detailed quarterly information to implement the sum-of-quarters approach.

At a meeting on December 24 that included the three directors of SNA divisions that calculate farm VPC, it was decided that IOD would move to IEAD's sum-of-quarters approach starting with the update of the 2002 I-O Tables in 2005, a decision that has now been implemented. This inevitably meant that IMAD was also locked into the sum-of-quarters appproach for its industry value added estimates.

Oddly enough, a main reason for making this change seems to have been a desire for greater consistency in the farm VPC estimates, a goal which was easily achievable simply by having IEAD switch to the annual approach for its annual estimates, which would not only have ensured that all four divisions used the same approach within SNA, but would have improved comparability of our estimates with the BEA's.

However, the move did not eliminate differences in the volume measure of farm VPC by IEAD and IMAD, since IEAD, unlike any other official entity in the world, calculates chain Fisher volume estimates with quarterly links, while IMAD calculates chain Fisher volume estimates with annual links, as prescribed by the System of National Accounts 1993 manual. While it does make IOD's farm VPC at current prices identical with that of IOD, IOD's estimate will no longer be the same as Agriculture Division's. Now Statistics Canada will have two different estimates of farm VPC appearing as components of value added by the agriculture sector, where previously there was only one. Also, the Canadian estimates for value added by the agriculture sector will be less comparable than they once

were with those of the United States, as well as with other countries that use the annual approach.[1]

Data Are Much Better for the Annual Approach than for the Sum-of-Quarters Approach

As good as they are, the Statistics Canada data are not equally good for calculating both annual and quarterly VPCs. While they do permit for reasonable estimates of quarterly inventory change, unlike those of many other countries, the annual data are much stronger than the quarterly, which in itself would seem to dictate treating the annual estimates as benchmarks to which quarterly estimates would be adjusted.

Briefly put, the main source of information on crop inventories comes from a Farm Stocks Survey conducted three times a year for the dates December 31, March 31 and July 31 by Crops Section of Agriculture Division. The survey covers cereals, oilseeds and specialty crops.

So for crops, while there is reliable information on annual change in physical stocks of the most important crops (i.e. the change from December 31 of one year to the next), only the first quarter has similarly reliable information. Since one can difference stocks between March 31 and December 31, the first quarter estimates are on the same footing with the annual estimates. The same cannot be said for the other quarters.

A farm supply-disposition (also called supply-demand) balance sheet reflecting activity on farms before grain enters commercial channels is used to generate stock estimates for the missing dates: June 30 and September 30. In addition to the opening inventory estimates themselves, supply consists of production, for which monthly estimates are available. In addition to the closing inventory estimates, disposition consists of deliveries, seed use, feed, waste and dockage.[2] The largest part of the deliveries are licenced grain deliveries for which weekly Canadian Grain Commission estimates are available, albeit with substantial quality problems and data lags that require adjustment. Seed use information is available from another survey conducted by Crops Section of Agriculture Division.

Feed, waste and dockage, however, is a residual category for which there are no monthly survey estimates. One of the main factors driving monthly consumption of feed is the

[1] The present author was co-author of a submission to Canada's SNA Steering Committee with a recommendation that CSNA terminology regarding chain volume measures, which largely copy those of the BEA, be replaced by others terms, which were not only more appealing, but more consistent with SNA 1993 or IMF standards. At that time, the decision was made to stay with the existing terminology because of the very high importance attached to CSNA being consistent with its American counterpart, even at the expense of being inconsistent with SNA 1993. Obviously the deference extended to the BEA in these matters of terminology does not extend to questions of methodology; the minutes of the December 24 meeting make no mention of BEA practice.

[2] Dockage is any material that must be removed from a commercial grain crop so that it may be assigned the highest grade for which it qualifies. See Cat.No.22-001-XIB, Vol.82, No.1, p.6.

monthly numbers of livestock, so that the feed estimates, and hence the crop stock estimates, are only as good as the monthly head counts for livestock. Residual estimation of the closing inventories for June 30 and September 30 is thus much less reliable because one of the categories required for this residual estimation is also a residual category.

If for crops, only first quarter estimates of physical changes in stocks are as reliable as annual estimates, for livestock categories, there is no quarter of the calendar year for which changes in head counts are available from surveys, as they are on an annual basis, except for hogs. The Livestock Survey makes a count of all livestock for January 1 and July 1, and of hogs for April 1 and October 1. Thus, unlike the Crop Survey all survey dates are for the first day of a calendar quarter, however only hogs are surveyed four times a year. And since the April and October hog surveys only have a quarter of the sample of the January livestock survey, even for hogs the quartery estimates of physical change in stocks are not of the same quality as the annual estimates.

Agriculture Division provides the CSNA with monthly estimates of inventory change on a timely basis for all livestock categories, and these are in fact used by the present author in calculating volume estimates of livestock production. Although there are no published or experimental estimates of VPC at current prices for livestock based on a sum-of-months approach all the data exist to calculate it.

This is not true for crops, for which only end-of-quarter stock estimates are presently available, but since marketings of grain are available on a weekly basis, there is no reason one could not calculate end-of-month stock estimates for crops and apply a sum-of-months approach to VPC estimation.

Official Guidelines on the Measurement of VPC

This measurement issue is one on which the SNA93 manual fails to be prescriptive, providing some ammunition for both sides in the dispute, although on balance it would seem its dictums provide more support for the annual approach. Generally speaking, the SNA93 manual seems to operate in an annual estimation framework and national accountants who must construct monthly or quarterly estimates are often left with no clear guidance. On the other hand, the IMF Quarterly National Accounts Manual seems to opt clearly and unambiguously for the sum-of-quarters approach.

According to SNA93, the basic principle of VPC measurement is “that output should be recorded at the time it is produced and valued at the same price whether it is immediately sold or otherwise used or entered into inventories for sale or use later. No output is recorded when goods produced previously are withdrawn from inventories and sold or otherwise used. It follows that entries into inventories must be valued at the basic prices prevailing at the time of entry, while withdrawals must be valued at the prices at which they are then sold.” (paragraph 6.58). SNA93 also says, and this is the crucial point: “When prices are stable, the measurement of changes in inventories is relatively simple. However, when there is inflation, significant price increases may occur while goods are

held in inventory. Holding gains accruing on goods held in inventory after they have been produced must not be included in the value of output".

The IMF Quarterly National Accounts Manual provides an example of how the quarterly VPC for coal inventories would be calculated using end-of-quarter information on book values at current prices and a monthly price index for coal. The change in inventories for 2001 Q1 is evaluated at first quarter prices and the possibility that there might indeed be some advantage to be gained in evaluating the VPC at average 2001 prices is not even considered. (For Canada at any rate, the calculation of farm VPC is much simpler than in the IMF manual's example and similar ones relating to non-farm inventories. The big bugbear of such estimates is usually to obtain good estimates of the inventory stocks in volume terms, using monthly price indexes and information on the turnover period of inventories. But for Canadian farm inventories, physical estimates of livestock and crops by category are available from survey information. It is only the revaluation of the changes in these physical stocks that is at issue.)

The IMF manual says that: "…higher frequency data reduce the possibility of uneven price and volume movements within the period. As a consequence, the annual sum of the quarterly valuation adjustments may be superior to annually calculated ones, unless there is some other compelling difference, *such as differences in coverage or detail* [emphasis added]. Similarly, if monthly data are available, the calculation should generally be done on a monthly basis for use in quarterly estimates." (See section 3.139). Thus, although the IMF manual favours the sum-of-quarters approach over the annual approach for measuring annual change, they judge it inferior to a sum-of-months approach, and presumably, as long as the coverage and detail were the same, they would judge a sum-of-months approach inferior to a sum-of-days approach.

They seem to be unperturbed by the problems that high-frequency valuation can create, which include the incorporation of holding gains in the valuation estimates, contrary to SNA93 principles, or the creation of negative implicit prices for VPC for commodities, even at the most detailed level. They are not explicitly concerned that price detail might dry up as they go from the annual to the quarterly frequency or from the quarterly to the monthly, although this may be a consideration when they write "as long as the coverage and detail are the same".

A Hypothetical Example

Now let us consider an example formulated by Kishori Lal, the former director general of the CSNA, in an earlier paper on the inventory change problem. In the first quarter a farmer produces 100 tonnes of a crop, and the market price per tonne is $10, the same price as in the year previous. Thus the value of output is $1,000. The farmer has no opening inventory as of the beginning of the first quarter. There is no opening inventory on January 1st, at the beginning of the year and of the first quarter. No output is sold and the entire output is added to inventory. If the VPC is calculated based on the same quarter prices, this addition to inventory is valued at $1,000.

In the second quarter, there is no production, but the entire first quarter crop is sold at the much higher second quarter price of $15. The second quarter VPC reflects a withdrawal from inventory which is valued at $1,500. Because the second quarter price is so much higher this VPC estimate includes a holding gain of $500 from the goods held in inventory.

In the third quarter, the farmer produces 200 tonnes but the price per tonne falls to $8. He sells 80 tonnes in the same quarter, leaving an inventory of 120 tonnes at the end of the third quarter, for a VPC of $960 ($8 x 120). This stock is entirely sold off at the much higher quarterly price of $12, creating a holding gain of $480 (($12-$8) x 120).

Calculating the sum of the quarterly VPCs, one has an annual VPC of -$980, although there is no change in the farmer's physical stocks of his crop at all between the beginning and the end of the year. He started and ended the year with no inventories.

The problem, of course, lies in the holding gains, which for the year are equal in value but opposite in sign to the VPC. This example, is of course, somewhat unrealistic as appies to Canadian agriculture where the winter is harsh and very few farmers harvest a winter and a fall crop, but it still illustrates in a very nice way the strengths and weaknesses of the different approaches.

All that is required to remove any holding gains from the quarterly VPC estimates is to evaluate the stocks at the same price in all quarters, i.e. at the annual price. The average sales price for the year is $11.93 per tonne (based on a sales value $3,580 with 300 tonnes sold). It can be seen that using this price for all quarters, the inventory accumulation of the first quarter is valued at $1,193 and is matched with a decumulation of the same value in the second quarter. The same thing happens in the third and fourth quarters where a $1,432 VPC in the third quarter is matched by a -$1432 VPC in the fourth quarter, so that the annual VPC takes a zero value.

In his own paper Lal showed the annual VPC generated by the annual approach, which he admitted was intuitively more attractive than the negative VPC generated by the sum-of-quarters approach. However, he neglected to show the quarterly estimates that would be generated using an annual price, which are also intuitively much more satisying than those generated using the quarterly approach. The inventory pattern in the first half of the year and the second half of the year is like the year as a whole. There are big swings in stocks within each semesters, but zero stocks when they begin and end.. For the first half of the year, the quarterly approach shows a VPC of -$500, while the annual approach shows a zero VPC. Again for the second half of the year, the quarterly approaach shows a VPC of -$480, while the annual approach shows a VPC of $0.

IEAD spokesmen have rightly pointed out that they do not know the annual price at the beginning of the year. Using their quarterly approach until an annual estimate became available would mean considerable revisions in their quarterly VPC estimates. However, it is neither necessary nor desirable to calculate estimates for the first three quarters of the year valuing each quarter at its own prices. This can introduce massive holding gains into

the estimates that will have to be removed when annual prices are later substituted. It would make much better sense to calculate the VPC for all quarters at the first quarter prices. Then the first quarter estimates would be consistent with the quarterly approach, while the remaining quarters would be calculated so that there are no holding gains in the estimates.

Of course, if minimization of revisions is the goal, some other set of prices than first quarter prices may more closely approximate the final annual prices. The table shows estimates based on replacing the average first quarter price by the average of first and second quarter prices in the second quarter and the average price for the first three quarters in the third quarter. (Unfortunately since there are no sales in the first quarter, a sales-weighted average of first and second quarter prices is equivalent to using first quarter prices.) The VPC's generated by these cumulative prices for the current year are shown in Table 1. It can be seen that after three quarters, there is little change between the VPC estimates based on partial year information and the final estimates based on four quarters of data.

The other point is that it is possible to calculate VPC estimates according to the quarterly approach and benchmark them to annual estimates based on the annual approach. For the current year, this should only be done once the annual estimate is available, although then the quarterly indicator series should be consistently based on the quarterly approach over the benchmarking range. The estimates in Table 1 were calculated just by assigning each quarter a share of the annual discrepancy between the annually-measured VPC and its sum-of-quarters counterpart based on the ratio of the absolute value of its VPC to the sum of absolute values of the VPCs for the year. Of course, more sophisticated benchmarking procedures would probably be used in a production context.

If one recalls the discussion of the data sources in a previous section, all the data currently exists to calculate quarterly livestock VPC using a sum-of-months approach rather than a quarterly approach, and could surely be created to do so for crops. Given that the weaknesses of the monthly stock estimates are essentially the same as the quarterly ones in relation to the much superior annual estimates, it can be safely assumed that data considerations are not responsible for IEAD opting for a quarterly approach to measuring quarterly VPC rather than a sum-of-months approach. That division does not seem to share the view of the IMF Quarterly Manual that "a quarterly estimate from the sum of monthly data … will be better than one calculated from quarterly data" although they obviously endorse the view that "the annual estimate would be better if made as a sum of the quarters than if made from annual data". (See the IMF Manual, section 3.140).

Therefore, IEAD appears to be concerned about the perverse effects on measured quarterly VPC one would encounter using the sum-of-months approach due to inventory changes in different months within the same quarter being evaluated at different prices. However, it is quite unconcerned about the perverse effects on measured annual VPC that currently prevail using the sum-of-quarters approach due to inventory changes in different quarters within the same year being evaluated at different prices.

In the same way, it has implemented chain volume measures of GDP with quarterly linking in spite of SNA93 guidelines that call for annual linking. The rationale for this is that one must ensure that the first quarter estimates of quarterly growth are true measures of volume change, which would not happen with once-a-year chaining with annual links. (It would be possible with once-a-year chaining with fourth-quarter links.) It doesn't matter that in doing this, the annual measures are not true measures of volume change, as they are in all countries that have followed the SNA93 guidelines. It is a different issue, but one that reveals a general prejudice in favour of quarterly estimates as opposed to annual estimates.

An Actual Example

We will now look at an actual example of VPC measurement which shows another perverse result possible using the sum-of-quarters approach: a negative annual implicit price for a commodity.[3]

Table 2 shows a summary of the Canada Supply/Disposition table from Agriculture Division for barley 1988. The upper half of the table lists physical change by quarter in tonnes, the bottom half multiplies the quantities by quarterly average prices to estimate VPC. The quarterly prices are weighted averages of surveyed monthly prices for marketings (deliveries) of barley, with weighting based on marketings. Similarly, the annual unit price of $86.72 is a weighted average of the quarterly prices.

The two columns on the right list annual estimates. SUM OF QTS represents the IEAD method, while ANNUAL CALC is the Agriculture Division method, which until this year was also used by IOD.

In quantity terms, the two figures are, of course, identical, both showing a reduction of 1.9 million tonnes. Valued in thousands of dollars, multiplying the physical change by the annual price of barley gives a VPC of $169.5 million. (The calculation is off slightly because the Can. figure is a sum of 10 provinces; this table shows only the Canada totals.)

By contrast, summing the VPCs over quarters yields +$87,541. The implicit price for the quarterly method is $-46.02 per tonne, while the range of prices is $56.50 to $116.58.

This result is, of course, again due to the incorporation of holding gains in the annual estimate of the VPC at current prices, given the strong increase in barley prices in the fourth and especially the second quarter when there was a depletion of stocks. It is another argument for benchmarking quarterly VPC estimates based on the quarterly approach to annual estimates based on the annual approach.

[3] This example is taken from a memo by Richards and Miller, 1997.

Table 1: Hypothetical Example of Quarterly Inventory Change (See Lal (2001))

	Y0	Q1	Q2	Q3	Q4	Y1
Output quantity		100	0	200	0	300
Sale quantity		0	100	80	120	300
Unit sale price	10	10	15	8	12	11.93
Cumulative unit sale price		10	15	11.89	11.93	
Output value		1,000	0	1,600	0	2,600
Sale value		0	1,500	640	1,440	3,580
Beginning-of-period quantity		0	100	0	120	0
End-of-period quantity		100	0	120	0	0
Start-of-period book value		0	1,000	0	960	0
End-of-period book value		1,000	0	960	0	0
Change in book value		1,000	-1,000	960	-960	0
VPC (valued at quarterly prices)		1,000	-1,500	960	-1,440	-980
Inventory holding gain		0	500	0	480	980
VPC (valued at Q1 prices for all quarters)		1,000	-1,000	1,200	-1,200	0
VPC (valued at annual prices) (Q2 update)		1,500	-1,500			0
VPC (valued at annual prices) (Q3 update)		1,189	-1,189	1,427		1,427
VPC (valued at annual prices) (final; Q4 update)		1,193	-1,193	1,432	-1,432	0
VPC (quarterly approach; benchmarked est.)		1,200	-1,200	1,152	-1,152	0

Table 2: Actual Example of Inventories for Barley

Value of Physical Change of Farm Stocks, 1988
Barley for Canada

	Q1	Q2	Q3	Q4	Sum of Quarters	Annual Estimate
Beginning Inventory (tonnes)	10,511,354	7,102,375	3,834,276	8,979,115		
Ending Inventory (tonnes)	7,102,375	3,834,276	8,979,115	8,609,303		
Physical Change (tonnes)	-3,408,979	-3,268,099	5,144,839	-369,812	-1,902,051	-1,902,051
Avg. FCR Price per Tonne	$56.50	$76.21	$104.21	$116.58		$86.72
Value of Physical Change in Inventories (,000)	-$192,766	-$246,795	$564,428	-$37,326	$87,541	-$169,511
Implicit Price (VPC/Tonnes)					-$46.02	$86.72

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