Chained-Dollar Indexes

Issues, Tips on Their Use, and Upcoming Changes

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BEA's introduction of chain-weighted indexes in 1996 significantly improved the accuracy of the U.S. estimates of the growth in real gross domestic product (GDP) and prices. These indexes use up-to-date weights in order to provide a more accurate picture of the economy, to better capture changes in spending patterns and in prices, and to eliminate the bias present in fixed-weighted indexes. A measure of their success is the widespread adoption of such indexes in economic measurement in other U.S. economic statistics and the near-universal movement by other industrial nations toward the use of such indexes for computing real GDP.

The move to chain-weighted indexes has not been painless. Such indexes are computationally difficult to use and do not provide the advantages of additivity that are present in fixed-weighted indexes. In order to provide some of the characteristics of fixed-weighted indexes, BEA developed chained-dollar indexes that are derived by multiplying the chain-weighted indexes by the current-dollar values of a specific reference year (currently, 1996).[1] For most components of GDP, these chained-dollar estimates provide a reasonable approximation of the component contribution to real GDP growth and of the relative importance of the components of GDP. Chained-dollar estimates also offer a limited ability to sum up components in user-defined groups such as GDP excluding government. However, for some components—such as computers and other high-tech equipment with rapid growth in real sales and falling prices—chained-dollar levels (as distinct from chain-weighted indexes and percent changes) overstate the relative importance of such components to GDP growth.[2] These problems have led to difficulties in using the chained-dollar measures in important applications of national accounts data, such as forecasting and interpreting economic changes.

This article discusses the advantages of chain-weighted indexes and the challenges posed by chained dollars, outlines further steps that BEA will be taking to address these issues in the 2003 comprehensive revision of the national income and product accounts (NIPAs), and provides suggestions for using chained dollars in ways that reduce biases and errors in forecasting and other applications where components need to be aggregated. Highlights of this article include the following:

- Chain-weighted indexes have provided a more accurate picture of the current economic recovery than fixed-weighted indexes. Real GDP as measured by the chain-weighted index has grown at a 2.7-percent annual rate during this recovery, a relatively slow growth rate compared with past recoveries.[3] However, using a fixed-weighted (1996) measure, growth would have been overstated by 1.6 percentage points, resulting in a misleadingly robust 4.3-percent growth rate.
- Because the chain-type indexes are weighted using current-period prices, the current-dollar shares of GDP provide a more accurate measure of the relative importance of components and are preferable to chained-dollar shares. Chained-dollar estimates, however, have provided a reasonable approximation of the relative importance of the five major components of GDP in recent quarters.[4]
- For the major components of GDP, when we simulate the effects of using chained dollars for forecasts and for calculations of contributions to growth, we find relatively small errors for recent periods.

1. As part of the comprehensive revision of the national income and product accounts that will be released in December 2003, the reference year will be updated to 2000.

2. The problems associated with chained-dollar levels for components with rapidly changing prices is the result of using a fixed base year in conjunction with a chain index whose weights change every period to reflect changes in relative prices. It is mathematically impossible to “force” chained-dollar levels to reflect both the current-period weights and period-to-period percent changes that are consistent with the chain index. As a result, BEA adopted chained-dollar levels that offer approximate additivity and that produce percent changes consistent with the chain index.

3. The current recovery is defined as from the recession trough in the third quarter of 2001 through the second quarter of 2003.

4. These five major components are personal consumption expenditures, gross private domestic investment, exports, imports, and government consumption expenditures and gross investment.

- For more detailed components—especially for goods and services with declining prices and rapidly rising real sales, such as computers and other high-tech products—the use of chained-dollar levels tends to overstate their relative importance and their contributions to GDP growth.
- Contributions to GDP growth of special interest aggregations, such as the sum of investment in computers and other high-tech equipment, are overstated using chained-dollar levels. Between 1995 and 2000, a simple aggregation by adding up chained-dollar estimates would suggest that high-tech investment accounted for about 21 percent of GDP growth rather than its actual contribution of about 17 percent.
- The use of current-dollar levels as GDP weights or simple “short-cut” chain-type indexes can virtually eliminate aggregation errors in forecasts and in estimates of contributions to GDP growth.
- In December, BEA will present additional tables that emphasize percent changes in the chain indexes for output and prices. It will also provide expanded tables of contributions to growth, of chain indexes for quantities and prices, of current-dollar estimates, and of current-dollar composition of GDP, which approximates the weights used in the calculation of real GDP that uses chain indexes.
- BEA will continue to make chain indexes available for all components of GDP, but the published tables will no longer show chained-dollar aggregates for certain components, such as computers, that do not provide a reasonable approximation of their relative importance in calculating the real GDP estimates. Fixed-weighted GDP estimates, which BEA has been disseminating as underlying detail, will also be discontinued.

Advantages of chain-type indexes

BEA’s chain-weighted indexes were introduced in 1996 to address “substitution bias” and the frequent revisions associated with using fixed-weighted indexes. The use of fixed-weighted measures of real GDP and of prices for periods other than those close to the base period results in a substitution bias that causes an overstatement of growth for periods after the base year and an understatement of growth for periods before the base year. For example, a fixed-weighted measure of real GDP based on 1996 prices would have overstated real GDP growth by 1.9 percentage points for the second quarter of 2003. Growth would have been a 5.1-percent using this measure, compared with the 3.3-percent yielded by BEA’s chain-type measure of real GDP. In the current recovery between the recession trough in the third quarter of 2001 and the second quarter of 2003, average annual real GDP growth would have been *overstated* by 1.6 percentage points by a fixed-weighted index; in the five major recoveries since 1959, real GDP growth would have been *understated* by about 0.7 percentage point. The net result would have been an overstatement of the strength of the current recovery relative to the average of the past recoveries of 2.4 percentage points (see table 1 and chart 1).

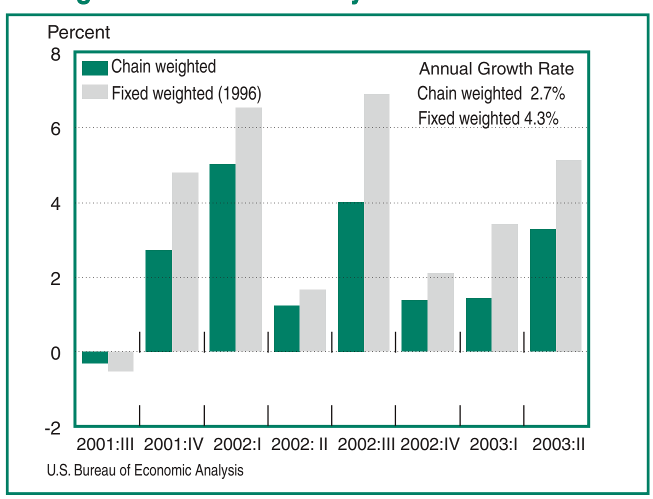
Table 1. GDP Growth During the Most Recent Quarter and Recessions

[Percent]

	Fixed-weighted index	Chain-weighted index	Difference
2003:II	5.1	3.3	1.9
Current recovery (2001:III–2003:II)	4.3	2.7	1.6
Average in five prior recoveries [1]	4.4	5.2	–0.7
Net overstatement of current recovery to past recoveries	....	....	2.4

NOTE. Numbers may not add due to rounding. The 1980:I–1980:III recession was excluded from this analysis since it did not have seven quarters of expansion following its trough.
1. Based on tracking growth from the trough of the recession through the next seven quarters (1960:IV–1962:III, 1970:IV–1972:III,1975:I–1976:IV, 1982:III–1984:II, and 1991:I–1992:IV).

Chart 1. Gross Domestic Product Growth During the Current Recovery



The use of current-period weights in the chain-type indexes eliminates the inconvenience and confusion associated with BEA’s previous practice of updating the weights and base years—and thereby rewriting economic history—about every 5 years. By minimizing substitution bias, the chain-type measures of real GDP growth also improves analyses of long-term issues, such as productivity, returns to investment, and the growth potential for the economy.

The introduction of chain-type indexes provides a measure of changes in real GDP that removes the effects of inflation and allows for consistent comparisons of GDP growth over time. The fundamental problem confronting the efforts to adjust GDP for inflation is that there is not a single inflation number but a wide spectrum of goods and services with prices that are changing relative to one another over time. Prior to 1996, BEA dealt with this problem by picking prices of a single base year. These estimates were relatively easy to understand and were referred to as fixed-weighted, or "constant-dollar," estimates. Technically, the estimates were Laspeyres quantity indexes that measure current-period output relative to that for the base period, 0, using base period prices:

Laspeyres quantity index (L):

$$L_{t,0} = \frac{\Sigma P_0 Q_t}{\Sigma P_0 Q_0},$$

where P_0 represents the prices for the base period, Q_0 represents the quantities for the base period, and Q_t represents the quantities for another period, t. The Laspeyres quantity index provides comparisons of relative quantities between periods. From the Laspeyres quantity index, the constant-dollar measure is obtained by scaling the index to its current-dollar value for the base period, creating an additive measure in units of base-year prices:

Fixed-weighted (constant-dollar) aggregate =

$$L_{t,0} \Sigma P_0 Q_0 = \Sigma P_0 Q_t.$$

The problem with using constant-dollar measures is that for periods far from the base year, base-year prices have little relevance. For example, the prices of defense equipment in 1996 are not appropriate for measuring the real changes in defense spending in the 1940s, just as 1996 computer prices are out of date for measuring the growth in information processing equipment in 2003. Not only are fixed weights irrelevant, but their use also results in the substitution bias and large revisions to GDP that occur when the base year is updated. Large revisions occur because commodities that experience rapid growth in output tend to be those for which prices increase less than average or decline. Thus, when real GDP is recalculated using more recent price weights, the commodities with strong output growth generally receive less weight, and the growth in the aggregate measure is revised down. These recalculations provide more accurate measures of growth in current periods near the base year because the base-year weights more closely reflect the prices of the economy in current periods; for earlier periods, however, the recalculations provide less accurate measures of growth because the weights are further away from the prices appropriate for those periods.

Chain indexes do not use a set of fixed weights; they use separate sets of weights for each time period. The formula used by BEA to calculate the chain indexes is known as the Fisher index, named after Irving Fisher, who originally developed this index to more consistently measure quantity and price changes over time. The Fisher formula generates two sets of weights for each pair of periods, *t*–1 and *t*, using prices from both the current period and the previous period, and it is calculated as the geometric mean of a Laspeyres index and a Paasche index. Recall from above that the Laspeyres index uses previous-period prices to value current- and previous-period output:

Laspeyres quantity index (L):

$$L_{t,t-1} = \frac{\Sigma P_{t-1} Q_t}{\Sigma P_{t-1} Q_{t-1}}.$$

Conversely, the Paasche index uses the prices of the current period to value current- and previous-period output:

Paasche quantity index (P):

$$P_{t,t-1} = \frac{\Sigma P_t Q_t}{\Sigma P_t Q_{t-1}}$$

Fisher quantity index (F):

$$F_{t,t-1} = \sqrt{L_{t,t-1} \times P_{t,t-1}}$$

Then the chain-type quantity index is formed by multiplying, or "chaining," together the Fisher indexes for each pair of periods:

Chain–type quantity index (I):

$$I_{t,0} = F_{t,t-1} \times F_{t-1,t-2} \times \ldots \times F_{1,0},$$

where period 0 is the reference year. (We use the term "reference year" rather than "base year" because for the chain-type quantity index, period 0 does not affect the weights used in the calculation of relative period-to-period changes and only serves as a point of reference.) Percent changes and growth rates between any pair of periods can be calculated directly from the quantity indexes. The most important feature of the chain-type index is that it uses different weights for each pair of periods, weights that represent the relevant prices or economic conditions for those periods. During periods when certain commodities are experiencing rapidly falling prices, the Laspeyres index overstates their contributions, while the Paasche index understates their contributions. In effect, the Fisher index is calculating the “middle ground” by taking an average of these two indexes.

Challenges of using chain-type indexes

One challenge posed by using chain-type indexes is that while they produce more accurate estimates of the growth in real GDP and its components, users of macroeconomic statistics need more than index numbers and percent changes. For more than 40 years, forecasting and analysis relied on constant dollars and were based on an additive accounting system in which real levels for the components of GDP added up to total GDP. Because the system was additive, the shares of the real components were measures of their relative importance in total real GDP. Similarly, in decomposing total GDP growth by component, the change in the constant-dollar values measured the component’s contribution to the change in the fixed-weighted aggregate. Economic analysts could construct—by simple subtraction or addition—the growth rates for user-defined aggregates, such as high-tech investment, energy-sensitive goods and services, or GDP excluding motor vehicles. Indeed, most large-scale macroeconomic models were built and estimated on the assumption that real GDP was additive.

To address the needs of its data users, BEA developed chained-dollar estimates and tables of contributions to growth rates based on chain-type quantity indexes for real GDP and its components. The chained-dollar estimates are simply the chain-type quantity indexes for real GDP (or a component) indexed to the relevant 1996 current-dollar value for GDP (or a component) rather than to 1.00 in 1996:

$$\text{Chained-dollar aggregate} = I_{t,0}\Sigma P_0 Q_0$$

Because the 1996 chained-dollar aggregate is just the quantity index scaled to 1996 current dollars, the percent changes in the chained-dollar aggregates are, by construction, equal to the percent changes in the quantity indexes for real GDP and its components.

For periods near the reference year, these chained-dollar indexes provide a reasonable approximation of the relative importance of major aggregates. However, they are approximations only and do not represent the weights or the relative importance of each component used in computing the Fisher chain indexes for GDP and for its components. The actual weights can be better approximated by each component’s relative share in current-dollar GDP for the most recent period.

The chained-dollar share represents the reference period’s (1996) share of GDP, adjusted for all the growth in the quantity, or real, index during the period between the reference period and the current period. This chained-dollar value ignores the changes in relative prices over that period, although it is the current-period prices that determine the relative importance of each component in real GDP for the current period. The weight of a component of real GDP is equal to what purchasers actually pay for a product in the current period, not what they might have paid in some past period. For goods and services whose prices have grown at a rate close to the overall inflation rate, chained-dollar values are not too far from the true weights, but for goods with rapidly falling prices—such as computers—the chained-dollar values overstate the relative importance of such components in GDP and total spending by not taking into account the rapid decline in prices that fueled the growth in the real quantities purchased.

For example, in 1996, a fairly powerful personal computer may have cost $5,000. Today, technological innovation has reduced the cost of an equivalent personal computer system to about one-ninth that amount. The use of chained dollars based on 1996 expenditures and prices—without allowing for the sharp drop in prices since that time—significantly overstates the relative value and impact of computers on the economy during the last half of the 1990s when computers experienced explosive growth and during the second and third quarters of 2003 when computer sales accelerated. Thus, in 1996, the purchase of 30 new high-end personal computers had a value roughly equal to a new home, but the use of this relative price to value such an investment in 2003 overstates by ninefold the value and the impact of that purchase in terms of jobs, wages, profits, and intermediate products relative to the purchases of homes and other capital goods.

This overstatement of the chained-dollar estimates for computers affects both the relative importance of computers and their contributions to growth in output and in prices. As a result, BEA recommends the use of the tables of contributions to growth (NIPA tables 8.2–8.6) rather than the use of calculations based on chained dollars.

The overstatement in the relative importance of computers can be seen by looking at the chained-dollar levels for computers relative to the level of GDP. Final sales of computers as measured in chained dollars would appear to represent 4.9 percent of GDP in the second quarter of 2003, whereas in current dollars, final sales of computers were only 0.7 percent of GDP. (Final sales of computers are said to "appear to represent" because chained dollars are not additive, and the sum of "GDP less final sales of computers" and "final sales of computers" is larger than GDP itself.)

The increasing overstatement of chained-dollar estimates for computers and their contribution to growth for periods after the base year of 1996 can be seen by looking at their contribution to growth over three periods: The last half of the 1990s, the last four quarters (2002:III–2003:II), and the second quarter of 2003. For 1995–2000, the share of real GDP growth accounted for by private investment in computers is about 11 percent using chained dollars, whereas the actual share is about 9 percent (see table 2 and NIPA table 8.2).[5] For the last four quarters, the average chained-dollar share of computer investment in GDP growth is about 35 percent, roughly 4.5 times its actual contribution to the growth of real GDP. In the second quarter of 2003, chained-dollar estimates suggest that investment in computers accounted for nearly half of the 3.3 percent GDP growth, while its true contribution to real GDP growth was 0.34 percentage point, about one-tenth of real GDP growth.

Table 2. Contribution Share of GDP Growth

[Percent]

	1995	1996	1997	1998	1999	2000	Average 1995–2000	Average 1997–2000
Computer investment:								
Based on chained dollars	8.5	8.1	9.2	12.8	17.1	11.7	11.2	12.7
Actual	12.6	9.4	8.2	8.4	8.3	4.5	8.6	7.9
High-tech investment: [1]								
Based on chained dollars	16.1	15.6	18.7	24.0	28.2	25.2	21.3	22.2
Actual	18.4	13.5	17.5	19.1	18.5	16.2	17.2	17.8

1. Defined as computers and peripheral equipment, software, and communications equipment.

The share of growth accounted for by user-defined totals, such as "high-tech" investment (computers, software, and communications equipment) will also be overstated if these totals are calculated as the sum of the chained-dollar estimates. High-tech investment appears to have accounted for 21 percent of real GDP growth between 1995 and 2000, whereas the actual contribution to GDP growth over this period was 17 percent.

Similar problems arise in measuring the contribution to, or relative importance of, changes in prices using chained dollars. For example, the use of chained dollars to weight the relative contribution of computers to overall inflation in recent years will overstate the importance of falling computer prices in restraining inflation. For 2002, the use of chained dollars to compute growth in the price index for gross domestic purchases excluding final sales of computers would have produced an inflation rate of 1.6 percent. This figure suggests that falling computer prices reduced inflation by about 0.4 percentage point rather than their actual reduction of about 0.2 percentage point.

Notwithstanding these problems associated with using chained dollars for goods and services with large changes in relative prices, chained dollars provide reasonable order-of-magnitude estimates of the relative importance of the major components of GDP for periods that are not too far from the reference year. As can be seen in table 3, chained dollars have provided a good general picture of the relative importance of the five major components of GDP in recent periods. Their share of chained-dollar GDP in recent quarters is within 1 to 3 percentage points of the actual weights for these components of real GDP.

Table 3. Component Shares of GDP: Chained-Dollar Estimate Versus Chain-Weighted Index

[Percent]

	2002 Chained-dollar estimate	2002 Chain-weighted index	2002 Difference	2003:II Chained-dollar estimate	2003:II Chain-weighted index	2003:II Difference
Personal consumption expenditures	69.7	69.0	0.7	69.9	69.9	0.0
Investment	16.8	15.7	1.1	16.7	15.0	1.7
Exports	11.2	10.6	0.6	11.0	9.5	1.5
Imports	–16.4	–13.5	–2.9	–16.6	–13.8	–2.8
Government	18.1	18.3	–0.2	18.4	18.7	–0.2

Note. Numbers may not add due to rounding.

Tips for forecasting and analysis using chained-dollar levels

The problems in using chained dollars extend to forecasts. Because virtually all macroeconomic models and forecasts were originally developed using additive fixed-weighted (or constant–dollar) estimates, the switch to using chained dollars was a major challenge for forecasters who had to (1) reestimate the behavioral relationships in their models to reflect the new unbiased NIPA component estimates and their lack of additivity in relationship to GDP and other subaggregates, (2) develop a new aggregation chain-weighted (Fisher) scheme based on estimates of quantities and

5. Figures are based on average annual contribution shares. When average quarterly contribution shares are calculated using chained dollars, they show more significant inaccuracies—a 16-percent share versus the actual share of 12 percent between 1995 and 2000.

prices for each of the components, and (3) develop the computer code needed to support these changes.[6]

These tasks were somewhat easier for those forecasters using large-scale models who had already produced separate price and quantity estimates for their major components, because these estimates could be used to create the necessary Fisher indexes. However, many desktop and other small-scale forecasters chose to keep their existing models and to use chained-dollar estimates in the same way that they had previously used constant-dollar estimates. As a consequence, when the chained-dollar forecasts for the components were added up, the results differed in level and in rate of growth from BEA's chained-dollar estimates of GDP. In order to better predict BEA's published estimates, these forecasters found that they had to estimate the residual between the sum of their forecasted chained-dollar components and BEA's aggregate chained-dollar estimates, which were based on the nonadditive current-period Fisher weights. (Often this forecast of the residual is derived by assuming that the residual for the next quarter is the same as that for the current quarter.) Thus, even if their forecasts for each of the components were exactly right, by adding up chained dollars rather than by basing the estimates on the current-period Fisher weights, an additional forecast error was introduced because of the use of the wrong weights in aggregation. While errors in component forecasts and revisions to GDP are probably larger than aggregation errors, the latter are easier to address than other sources of errors.

Indeed, aggregation errors can be virtually eliminated by using one of two fairly simple higher level aggregation methods that are good approximations of the detailed level Fisher weights actually used by BEA in estimating GDP. The first method essentially uses the most recent current-dollar levels to "weight" forecasted estimates of the percent change of each of the major components of real GDP and then sums them up to calculate real GDP (with the current quarter as the base period) and the change in real GDP. The second method requires separate estimates of quantities and of prices for each of the major components that are then used to estimate a higher level Fisher index. Both methods produce GDP growth rates that are very close to the results produced by the detailed Fisher index used by BEA that incorporates

6. See Chris Vavares, Joel Prakken, and Lisa Guirl, "Macro Modeling with Chain-Type GDP," *Journal of Economic and Social Measurement* 24 (1998): 123–142.

Table 4. One-Quarter-Ahead Forecasts Using Current-Dollar Levels

	A	B	C	D	E	F	G	H	I	J	K	L	M
1		Percent change from preceding period				Billions of dollars							
2		Forecasted growth				Published				Forecast			
3		2002			2003	2002				2002			2003
4		II	III	IV	I	I	II	III	IV	II	III	IV	I
5	Calculation									F*(1+B)^.25	G*(1+C)^.25	H*(1+D)^.25	I*(1+E)^.25
6	Personal consumption expenditures:												
7	Durable goods	2.0	22.8	–8.2	–2.0	859	857	898	874	863	902	879	869
8	Nondurable goods	–0.1	1.0	5.1	6.1	2,085	2,108	2,117	2,150	2,085	2,114	2,143	2,182
9	Services	2.7	2.3	2.2	0.9	4,230	4,290	4,346	4,402	4,258	4,314	4,370	4,411
10	Gross private domestic investment	7.9	3.6	6.3	–5.3	1,559	1,588	1,597	1,628	1,589	1,602	1,622	1,606
11	Fixed investment:												
12	Nonresidential:												
13	Structures	–17.6	–21.4	–9.9	–2.9	288	275	259	254	275	259	253	252
14	Equipment and software	3.3	6.7	6.2	–4.8	838	841	850	863	845	854	863	852
15	Residential	2.7	1.1	9.4	10.1	463	469	470	487	466	470	481	498
16	Change in private inventories [1]									4	19	25	3
17	Net exports of goods and services:												
18	Exports:												
19	Goods	15.9	4.1	–11.5	1.9	680	709	723	703	705	717	701	706
20	Services	10.7	5.9	8.0	–8.0	298	309	316	323	305	313	322	316
21	Imports:												
22	Goods	27.9	3.4	6.2	–6.7	1,102	1,203	1,221	1,242	1,172	1,213	1,240	1,221
23	Services	–2.1	3.1	13.0	–4.0	235	241	251	259	234	243	258	256
24	Government consumption expenditures and gross investment:												
25	Federal	7.5	4.3	11.0	0.7	672	688	698	717	684	695	716	718
26	State and local	–1.7	2.2	1.2	0.2	1,267	1,272	1,283	1,294	1,262	1,279	1,287	1,295
27	Gross domestic product					10,313	10,377	10,506	10,589	10,346	10,480	10,542	10,626
28	**Forecasted growth in GDP**									**1.3**	**4.0**	**1.4**	**1.4**
29	Published growth in GDP									1.3	4.0	1.4	1.4
30	Forecasted growth error									0.0	0.0	0.0	0.0
31	**Mean absolute error over four quarters**												**0.01**

NOTE. Numbers may not add due to rounding.
1. Since change in private inventories can be positive or negative, it is calculated implicitly by calculating gross private investment and subtracting fixed investment components.

over 1,500 separate price and quantity estimates.

For example, if desktop forecasters in the first quarter of 2002 wanted to estimate real GDP growth for the second quarter of 2002 using a current-dollar-weighting method, they would first have estimated the real quarterly growth rates for each of the components of GDP used in the forecast as shown in column B of table 4.[7] (To enhance the comprehension of the forecast methods outlined in this article, tables 4–6 appear in spreadsheet format.) Next, these growth rates would have been used to estimate current-dollar levels for the second quarter. Notice that the fourth root of one plus the annualized growth rate must be used to convert to quarterly growth rates (see the "Calculation" row for columns J–M). Each of the components for the first quarter would have been multiplied by its estimated growth rate, and the forecasted levels would then have been summed to produce a weighted average growth rate for real GDP. Because the use of the current-dollar levels for the previous quarter as weights approximates the weights used in the quarterly Fisher chain index, the current-dollar weighting method produces aggregates that are fairly accurate for making forecasts.

As can be seen by comparing table 4 with table 5, the use of the current-dollar levels from the latest quarter as a base can significantly reduce aggregation errors in forecasts. As shown in table 5, for the second quarter of 2002, even with perfect foresight, simply adding up the forecasted levels for each of the chained-dollar components at the level of aggregation used by many forecasters (that is, assuming that the residual is unchanged) would have produced a real GDP growth rate of 0.9 percent, about 0.3 percentage point below the published rate of 1.3 percent. However, the use of the of first-quarter current-dollar GDP component levels would have produced a weighted-average growth rate of 1.3 percent, about the same as the published value. Over a four-quarter forecast horizon, the use of the current-dollar levels to estimate the next quarter's

7. In order to isolate the impact of aggregation problems, perfect foresight is assumed, and the annual growth rates in columns B–E correspond to the published estimates. Note that in order to get more significant digits, growth rates carried through the spreadsheet are based on calculating the rate of change for published chained-dollar levels, which have the same accuracy as the three-decimal-place quantity indexes available as underlying estimates.

Table 5. One-Quarter-Ahead Forecasts Using Chained-Dollar Levels

	A	B	C	D	E	F	G	H	I	J	K	L	M
1		Percent change from preceding period				Billions of chained (1996) dollars							
2		Forecasted growth				Published [1]				Forecast			
3		2002			2003	2002				2002			2003
4		II	III	IV	I	I	II	III	IV	II	III	IV	I
5	Calculation									F*(1+B) ^.25	G*(1+C) ^.25	H*(1+D) ^.25	I*(1+E) ^.25
6	Personal consumption expenditures:												
7	Durable goods	2.0	22.8	–8.2	–2.0	976	981	1,032	1,011	981	1,032	1,011	1,005
8	Nondurable goods	–0.1	1.0	5.1	6.1	1,921	1,921	1,926	1,950	1,921	1,926	1,950	1,979
9	Services	2.7	2.3	2.2	0.9	3,642	3,666	3,687	3,707	3,666	3,687	3,707	3,715
10	Gross private domestic investment	7.9	3.6	6.3	–5.3	1,551	1,584	1,601	1,626	1,581	1,598	1,626	1,604
11	Fixed investment:												
12	Nonresidential:												
13	Structures	–17.6	–21.4	–9.9	–2.9	243	232	218	213	232	218	213	211
14	Equipment and software	3.3	6.7	6.2	–4.8	954	961	977	992	961	977	992	980
15	Residential	2.7	1.1	9.4	10.1	384	386	387	396	386	387	396	406
16	Change in private inventories [2]					–29	5	19	26	2	16	25	8
17	Net exports of goods and services:												
18	Exports:												
19	Goods	15.9	4.1	–11.5	1.9	738	766	774	750	766	774	750	754
20	Services	10.7	5.9	8.0	–8.0	292	300	304	310	300	304	310	304
21	Imports:												
22	Goods	27.9	3.4	6.2	–6.7	1,250	1,329	1,340	1,361	1,329	1,340	1,361	1,337
23	Services	–2.1	3.1	13.0	–4.0	226	224	226	233	224	226	233	231
24	Government consumption expenditures and gross investment:												
25	Federal	7.5	4.3	11.0	0.7	598	609	615	631	609	615	631	633
26	State and local	–1.7	2.2	1.2	0.2	1,099	1,095	1,101	1,104	1,095	1,101	1,104	1,105
27	Gross domestic product before residual					9,343	9,367	9,473	9,496	9,364	9,470	9,495	9,530
28	Residual	0.0	0.0	0.0	0.0	20	25	12	22	20	25	12	22
29	Gross domestic product					9,363	9,392	9,486	9,518	9,385	9,496	9,507	9,552
30	**Forecasted growth in GDP**									**0.9**	**4.5**	**0.9**	**1.4**
31	Published growth in GDP									1.3	4.0	1.4	1.4
32	Forecasted growth error									–0.3	0.4	–0.5	0.0
33	**Mean absolute error over four quarters**												**0.31**

NOTE. Numbers may not add due to rounding.

1. Published chained-dollar level for gross private domestic investment based on aggregation of lower chained-dollar levels. Published residual based on reported chained-dollar GDP less chained-dollar components used in forecast.

2. Because change in private inventories can be positive or negative, it is calculated implicitly by calculating gross private investment and subtracting fixed investment components.

component and real GDP forecast would have reduced the forecast error due to aggregation from 0.31 percentage point to 0.01 percentage point.

The use of a higher level Fisher index—sometimes referred to as a “Fisher of Fishers”—is a somewhat more complicated forecasting method, but it produces similar reductions in aggregation errors. The extra complexity of the “Fisher of Fishers” is balanced by the conceptual consistency with the actual Fisher index used in computing GDP and the greater accuracy that could be obtained during periods of rapid price changes for which the use of the current-quarter and next-quarter weights would be more stable and subject to less revision than the use of only current-quarter weights.

The first step in estimating the “Fisher of Fishers” is to calculate a Laspeyres index. For a second-quarter 2002 forecast, the denominator in the Laspeyres index is simply the current-dollar value for the first quarter (see table 6). The numerator is the sum of the forecasted quantities for the second quarter valued in the first quarter’s prices.

The second step is to form the Paasche index where the numerator is the second-quarter output forecasted in current dollars. The denominator is the sum of the first quarter’s quantities multiplied by the second-quarter price forecasts. The Fisher index is the square root of the Laspeyres index multiplied by the Paasche index, which is a geometric mean. Finally, the growth rate for real GDP is found by raising the second-quarter “Fisher-of-Fishers” forecast to the fourth power and subtracting one.

The use of the “Fisher of Fishers” to estimate second-quarter growth in GDP would have produced a growth rate of 1.24 percent, 0.02 percentage point less than the published real GDP growth. Over a four-quarter forecast horizon, the use of a “Fisher of Fishers” would have produced an average GDP growth rate of 2.0 percent and would have reduced the forecast error due to aggregation from 0.31 percentage point to 0.03 percentage point, and over eight quarters, from 0.25 percentage point to 0.04 percentage point.

Table 6. One-Quarter-Ahead Forecast Using Fisher of Fishers

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1		Percent change from preceding period		Levels in billions of dollars						Laspeyres		Paasche		Fisher
2		Forecasted growth		Published			Forecast							
3		Nominal	Real	Current-dollar level	Chained-dollar level	Deflator	Current-dollar level	Chained-dollar level	Deflator					
4		2002:II		2002:I			2002:II			2002:II		2002:II		2002:II
5	Calculation					D/E	D * (1+B)^.25	E * (1+C)^.25	G/H	F * H	sum(J)/ D	E * I	sum(G)/ sum(L)	(K * M)^.5
6	Gross domestic product			10,313	9,363	1.101					1.003		1.003	1.003
7	Personal consumption expenditures			7,174	6,514	1.101								
8	Durable goods	–0.9	2.0	859	976	0.880	857	981	0.874	863		853		
9	Nondurable goods	4.5	–0.1	2,085	1,921	1.085	2,108	1,921	1.098	2,085		2,109		**Forecast**
10	Services	5.7	2.7	4,230	3,642	1.161	4,290	3,666	1.170	4,258		4,261		9,392
11	Gross private domestic investment			1,559	1,554	1.003								**1.24%**
12	Fixed investment			1,589	1,576	1.008								
13	Nonresidential			1,127	1,188	0.948								
14	Structures	–17.1	–17.6	288	243	1.186	275	232	1.188	275		289		***Less:***
15	Equipment and software	1.1	3.3	838	954	0.879	841	961	0.874	845		834		**actual**
16	Residential	5.4	2.7	463	384	1.206	469	386	1.214	466		466		9,392
17	Change in private inventories [1]			–30	–29	0.985	3	5	0.990	5		–29		**1.25%**
18	Net exports of goods and services			–360	–447	0.806								
19	Exports			977	1,031	0.948								
20	Goods	18.6	15.9	680	738	0.921	709	766	0.926	705		684		
21	Services	15.8	10.7	298	292	1.019	309	300	1.030	305		301		***Equals:***
22	Imports [2]			1,338	1,477	0.905								**forecast error**
23	Goods	41.8	27.9	1,102	1,250	0.882	1,203	1,329	0.905	1,172		1,131		–0.4
24	Services	9.9	–2.1	235	226	1.043	241	224	1.074	234		242		**–0.02%**
25	Government consumption expenditures and gross investment			1,939	1,697	1.143								
26	Federal	10.0	7.5	672	598	1.124	688	609	1.131	684		676		
27	State and local	1.3	–1.7	1,267	1,099	1.153	1,272	1,095	1.162	1,262		1,277		

NOTE. Numbers may not add due to rounding.

1. Assumes that percent contribution to GDP growth is known (chained-dollar level and current-dollar level are known). The deflator is based on the implicit price deflators for private inventories (see NIPA table 7.16B).

2. Imports are actually subtracted in the summation calculations for the Laspeyres and Paasche indexes.

Table 7 summarizes the improvements in forecast accuracy that can be obtained by using either current-dollar weights or a "Fisher of Fishers" at different levels of aggregation. During the current recovery and at the five-component level, forecasts based on current-dollar weights would have had a mean absolute aggregation-related forecast error of 0.012 percentage point, and forecasts based on the "Fisher of Fishers" would have had a mean absolute error of 0.003 percentage point. At the more detailed levels of aggregation used by many forecasters, the approximations are close to the published GDP growth rates—and significantly better than simple addition of chained-dollar forecasts—although they exhibit somewhat larger aggregation errors.

Forthcoming changes to the NIPAs

A number of new and redesigned tables will be introduced as part of the comprehensive revision of the NIPAs that will be published next month.[8] Among the changes that will address some of the problems associated with chained dollars (as distinct from chain-type indexes) are

- New tables that present relative shares of the components of GDP and gross domestic income in current dollars in order to aid in the analysis of the relative importance of the components and
- New tables that highlight percent changes and contributions to percent change in the components of GDP to provide additional information on the sources of change in the economy.

In line with these changes, BEA will eliminate some of the most misleading aspects of the chained-dollar estimates by dropping, or "leadering out," those components, such as computers, whose chained-dollar levels are far from their relative importance in the Fisher chain index. Armed with the additional information provided in the new tables, users should be better equipped to find the information they seek without relying on chained-dollar estimates, and they can thereby avoid the problems associated with the estimates.[9] BEA also plans to discontinue producing fixed-weighted estimates of constant-dollar GDP, which had been made available as underlying detail estimates.

In the next year or two, BEA will also introduce an interactive section of its Web site that will permit users to define their own aggregates and to compute the relative importance and contributions to growth of these user-defined aggregates. This new feature will make it more convenient for users to work with the chain-type aggregates.

8. See Nicole Mayerhauser, Shelly Smith, and David F. Sullivan, "Preview of the 2003 Comprehensive Revision of the National Income and Product Accounts: New and Redesigned Tables," Survey of Current Business 83 (August 2003): 7–31.

9. BEA will continue to make chained-dollar estimates available on its Web site, but it cautions users of these estimates to be aware of the problems involved in their use and suggests the use of the techniques cited above for ameliorating the problems associated with chained dollars.

Table 7. Summary of Forecast Methods

[Percent]

Forecasting method used	2001:III–2003:II	
	Average growth rate	Mean absolute error
Actual	2.36	....
Current-dollar method:		
High level	2.37	0.012
Medium level	2.37	0.018
Low level	2.37	0.018
Chained-dollar method:		
High level	2.24	0.137
Medium level	2.37	0.236
Low level	2.37	0.199
Fisher of Fishers:		
High level	2.36	0.003
Medium level	2.34	0.037
Low level	2.34	0.036

Note. High level = C + I + G + (X – M).
Medium level is NIPA table 1.1 excluding federal government breakdown.
Low level is medium level, including detailed breakdown of private fixed investment in equipment and software shown in NIPA table 5.4.