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Integrating Industry and National Economic Accounts
First Steps and Future Improvements

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6.1 Introduction

As part of its continuing efforts to improve the system of economic accounts, the Bureau of Economic Analysis (BEA) has begun a series of strategic initiatives to ultimately integrate the gross domestic product (GDP)–by-industry, annual input-output (I-O), and benchmark I-O programs within the industry accounts, as well as to integrate the industry accounts with the National Income and Product Accounts (NIPAs).[1] Full achievement of this goal will require several years of effort by the BEA, as well as the continuing participation and cooperation by other statistical agencies, particularly the Bureau of the Census and the Bureau of Labor Statistics (BLS), to further enhance source data. In the interim, the BEA

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1. In addition, it is the BEA's long-run goal to integrate the industry accounts and NIPAs with related regional accounts, namely gross state product (GSP) by industry and regional I-O multiplier estimates. Consistency between the annual I-O accounts and the GDP-by-industry accounts will improve the quality of the GSP accounts, and any increase in timeliness of the GDP-by-industry estimates will be reflected in more speedy delivery of the GSP estimates. Consistent and better measures of value added would also potentially strengthen the links between the GSP accounts and the regional I-O multiplier estimates.

has moved forward with integrating two out of three of its industry programs—specifically the merging of the GDP-by-industry accounts with the annual I-O accounts. Initial results of this effort were released in June 2004 as part of BEA's five-year comprehensive revision.

The integration of the GDP-by-industry accounts with the annual I-O accounts is the most recent in a series of improvements to the industry accounts. These improvements include the following: resuming the publication of the annual I-O accounts; accelerating the release of the annual I-O accounts to within three years after the end of the reference year; expanding the GDP-by-industry accounts to include gross output and intermediate inputs for all industries; developing an accelerated set of GDP-by-industry accounts that are available with a lag of four months after the end of the reference year; and continuing to work closely with the Bureau of the Census on new initiatives to improve the quality and the timeliness of the source data used to prepare the industry accounts.[2]

With these improvements to the industry accounts in place, as well as with the general improvements made to the quality of industry source data, the BEA is ready to integrate the annual I-O accounts and the GDP-by-industry accounts as a first step toward full integration.[3] For purposes of the current paper, this integration is being referred to as "partial integration" and is the first tangible result of the initiative to reach the BEA's data users.

This partial integration could have been achieved through a variety of methods. For example, many countries produce integrated annual I-O accounts and GDP-by-industry accounts by assuming that the industry ratios of intermediate inputs to gross output do not change from the most recent set of benchmark I-O accounts. With this assumption, they then use these ratios to estimate a time series of value added by industry from the annual source data on gross output by industry. The BEA has taken a very different approach in developing its integration methodology because of the richness of the source data that are available in the United States. For example, the Bureau of the Census, the BLS, and the Internal Revenue Service (IRS) provide data that can be used to estimate value added by industry in various ways. However, the quality of these source data varies by data series and by industry, particularly in terms of their relative coverage and definitional consistency. As a result, the BEA has developed a method that ranks the available source data based on measures of coverage and consistency, among other factors, and then estimates a balanced set of annual

2. For an overview of the accounts see Lawson (2000); for a presentation on the resumed annual I-O accounts see Lawson, Okubo, and Planting (2000); for the presentation of the expanded GDP-by-industry accounts see Lum, Moyer, and Yuskavage (2000); and for a discussion of the accelerated GDP-by-industry estimates see Yuskavage (2002).

3. For a discussion on integrating the industry accounts, see Yuskavage (2000).

I-O accounts and GDP-by-industry accounts that incorporate the resulting weighted average of these source data. In this manner, the BEA's integrated annual I-O accounts and GDP-by-industry accounts will provide a more consistent and a more accurate set of estimates.

For full integration of the industry accounts, the measure and level of value added by industry for the industry accounts will be based on the benchmark I-O accounts, beginning with the 2002 accounts. These accounts are prepared for years of the quinquennial economic census and are currently used to establish the measure and level of final expenditures by use category contributing to GDP in the NIPAs. Annual updates of the integrated industry accounts would be based on less comprehensive survey and administrative record data available in nonbenchmark years. For full integration, the measures of value added by industry would be independent of the NIPA measures of gross domestic income (GDI) and would provide a "feedback" loop to the NIPAs that would improve the estimates of the commodity composition of GDP final expenditures.[4] To achieve this ambitious goal, the BEA is working cooperatively with the Census Bureau, BLS, and other statistical agencies to make the necessary improvements to the quality and coverage of the underlying source data, particularly for information on industry expenses.

This chapter has five sections and three appendices. The first section is this introduction. The second section describes in greater detail the partial integration being achieved in the short run. The third section presents the BEA's vision for full integration in the long run, including some of the major requirements for achieving this goal as well as the major benefits. The fourth section describes the methodology developed for the partial integration of the annual industry accounts. The last section outlines the future steps required to reach the goal of full integration. The appendices include an expanded description of the probability-based method used to develop a weighted-average estimate of each industry's gross operating surplus; a detailed description of the new balancing procedure developed for automating production of the annual I-O tables; and a statement of the computation method used to estimate chain-type price and quantity indexes in the GDP-by-industry accounts.

Highlights of the partial integration methodology are as follows:

4. The BEA currently uses two approaches to measure GDP: the expenditures approach and the income approach. The expenditures approach measures GDP as the sum of consumption spending, investment spending, government expenditures, and exports minus imports. The income approach measures GDP as the sum of compensation of employees; taxes on production and imports, less subsidies; and gross operating surplus. These approaches allow maximum use of up-to-date, high-quality economic indicators from the Bureau of the Census, the IRS, and the BLS to produce timely, reliable measures of the economy's current performance.

- It allows the BEA to incorporate the most timely and highest-quality source data available into both the annual I-O accounts and the GDP-by-industry accounts.
- The quality of the annual industry accounts is improved because the accounts are prepared within a balanced I-O framework; that is, all the components of the accounts are in agreement within a balanced row-and-column framework.
- The annual I-O accounts and the GDP-by-industry accounts are now released concurrently and present fully consistent measures of gross output, intermediate inputs, and value added by industry.
- The annual I-O accounts are available within one year after the end of the reference year or two years earlier than previously.
- The annual I-O accounts are now presented as a consistent time series; as a consequence, the annual I-O accounts are more useful for analyses of trends over time.

6.2 Partial Integration: The First Step

The BEA prepares two sets of national industry accounts: the I-O accounts, which consist of the benchmark I-O accounts and the annual I-O accounts, and the GDP-by-industry accounts. Both the I-O accounts and the GDP-by-industry accounts present measures of gross output, intermediate inputs, and value added by industry; however, they are often inconsistent because of the use of different methodologies, classification frameworks, and source data. These inconsistencies are frustrating to data users, who would like to be able to combine the richness of information from each for their own applications. The goal of partial integration is to eliminate these inconsistencies, as well as to improve the accuracy of the combined accounts by drawing on their relative strengths in methodologies and source data. In this section, the traditional I-O and GDP-by-industry methodologies are reviewed and the comparative advantages of each are examined in the context of an integrated methodology that produces both sets of accounts.

6.2.1 The Traditional I-O Accounts Methodology

The I-O accounts present a detailed picture of how industries interact to provide inputs to, and use output from, each other to produce the nation's GDP. The I-O accounts consist of benchmark I-O accounts and annual I-O accounts. The benchmark I-O accounts are prepared every five years and are based on data from the quinquennial economic census covering most businesses.[5] The annual I-O accounts update the most recent benchmark I-O accounts, and, although they are more timely than the benchmark

5. For more information, see Lawson et al. (2002).

I-O accounts, they are generally less detailed because they rely on annual data based on smaller sample surveys.[6] At present, the I-O accounts are prepared only in current dollars.[7]

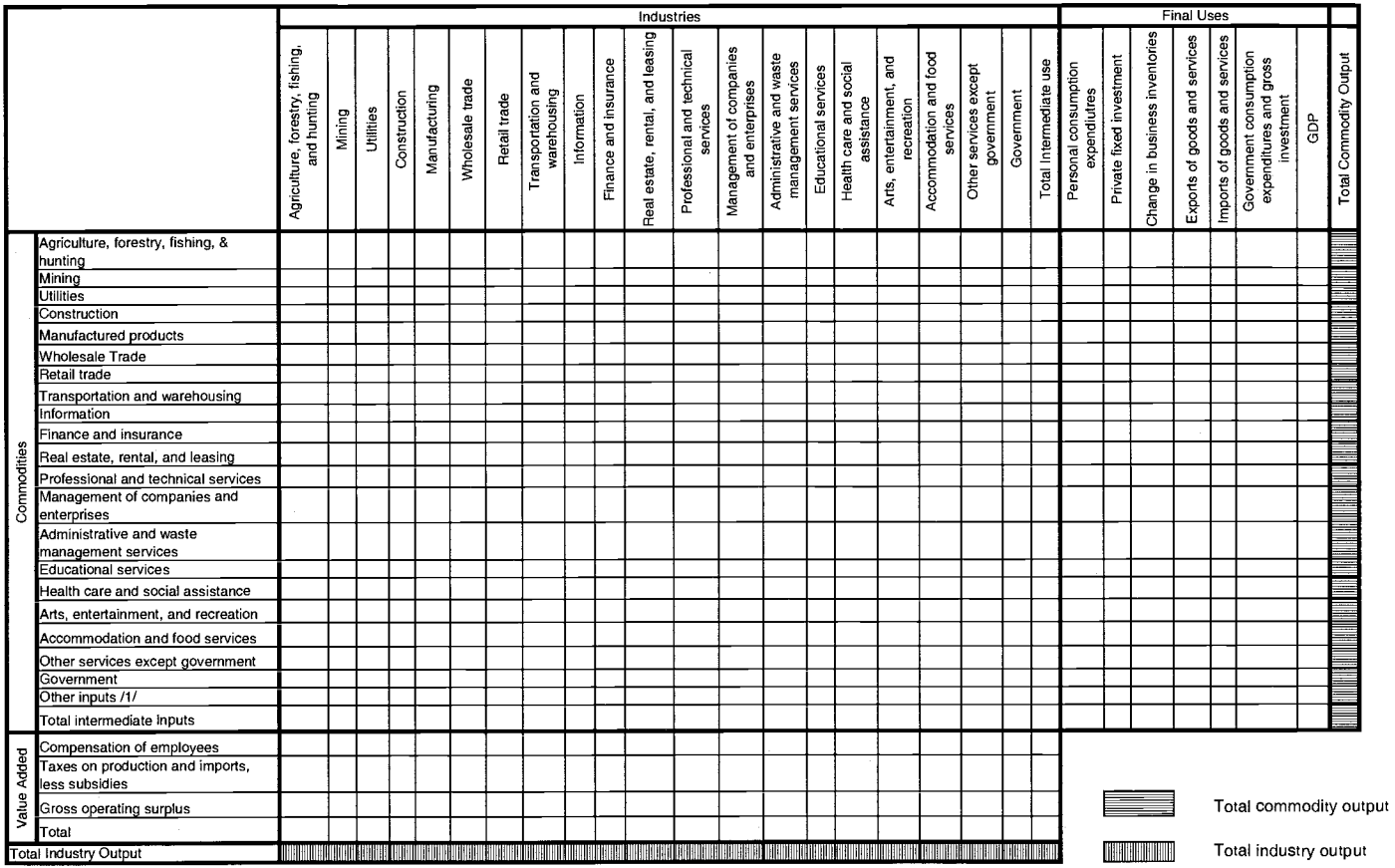
Both the benchmark and the annual I-O accounts are prepared within a balanced row-and-column framework that is presented in two tables: a "make" table and a "use" table. The make table shows the commodities that are produced by each industry, and the use table shows the commodities that are used in industry production and that are consumed by final users. In the use table, the columns consist of industries and final uses (figure 6.1). The column total for an industry is its gross output (consisting of sales or receipts, other operating income, commodity taxes, and inventory change). The rows in the use table consist of commodities and value added. The commodities are the goods and services that are produced by industries or imported and that are consumed either by industries in their production processes or by final users. The commodities consumed by industries in the production process are referred to as intermediate inputs (consisting of energy, materials, and purchased services). Value added in the I-O accounts is computed as a residual—that is, as gross output less intermediate inputs by industry. In concept, this residual, which represents the sum of the costs incurred and the incomes earned in production, consists of compensation of employees, gross operating surplus, and taxes on production and imports, less subsidies.[8] GDP equals valued added summed over all industries, and it also equals final uses summed over all commodities.

The I-O accounts have traditionally served two major purposes, both of which have focused on information about the use of commodities and which have supported the BEA's NIPAs. First, the accounts have provided the NIPAs with best-level estimates of the commodities that comprise final expenditures for GDP in benchmark years. Second, they provide the NIPAs with information to split estimates of commodities produced annually into their business (intermediate) and final consumer components—information that is critical for estimating GDP final expenditures in nonbenchmark years. Because of their importance in determining the levels of GDP in the NIPAs, the I-O accounts have traditionally focused more on the

6. For more information, see Lawson, Okubo, and Planting (2000) and Planting and Kuhbach (2001).

7. The BEA is beginning research to explore the feasibility of preparing real (inflation-adjusted) I-O accounts.

8. Previously, these costs and incomes were classified as either compensation of employees, property-type income, or indirect business tax and nontax liability. These new classifications are consistent with the aggregations introduced as part of the comprehensive NIPA revision; see Moulton and Seskin for more information. Specifically, all the nontax liabilities except special assessments are removed from indirect business tax and nontax liability, and the remainder of this category is renamed "taxes on production and imports"; the nontax liabilities except special assessments are added to property-type income; subsidies are removed from property-type income, and the remainder of this category is renamed "gross operating surplus"; and subsidies are netted against the value of taxes on production and imports.



1. Includes noncomparable imports, scrap, used goods, inventory valuation adjustment, and rest-of-the-world adjustment.
GDP: Gross domestic product

Fig. 6.1 Use table: Commodities used by industries and final uses

Source: U.S. Bureau of Economic Analysis.

commodity composition of the economy and less on the measures of value added by industry.

6.2.2 The Traditional GDP-by-Industry Accounts Methodology

In contrast to the I-O accounts, the GDP-by-industry accounts have traditionally focused on the industry composition of the U.S. economy and the relative performance of these industries as reflected in their measures of value added. The GDP-by-industry accounts are particularly suited for time series analysis of changes in industry shares of GDP and contributions to GDP growth. They provide annual estimates of gross output, of intermediate inputs, and of value added by industry and the corresponding price and quantity indexes.[9]

The GDP-by-industry accounts use a different estimating approach than that used for the I-O accounts. They measure value added by industry as the sum of the costs incurred and the incomes earned in production. Value added by industry is estimated as the sum of the industry distributions of compensation of employees, gross operating surplus, and taxes on production and imports, less subsidies (figure 6.2). In the GDP-by-industry accounts, total intermediate inputs by industry are measured as a residual—that is, total intermediate inputs equal gross output less value added for an industry.

The GDP-by-industry estimates are based on data from three primary sources. Gross output by industry is based on establishment-based annual survey data from the Bureau of the Census that are used to extrapolate best-level estimates from the most recent set of benchmark I-O accounts. The measures of value added by industry are derived from the industry distributions of the components of GDI from the NIPAs, which, in turn, are based on establishment-based data from the BLS and on enterprise-based annual tax return and administrative record data from the IRS.

Real measures of gross output and intermediate inputs by industry are estimated by deflating with detailed price indexes. Price indexes and quantity indexes are derived for each industry's gross output, of intermediate inputs, and of value added.

6.2.3 Combining the Two Methodologies

The primary strength of the I-O methodology is the balanced row-and-column framework in which the detailed estimates of gross output and intermediate inputs by industry are prepared; this framework allows for a simultaneous look at both the economy's industries and commodities. The primary strength of the GDP-by-industry accounts methodology is the direct approach to estimating a time series of value added by industry from high-quality source income data. The methodology for partial integration

9. For more information, see Lum, Moyer, and Yuskavage (2000).

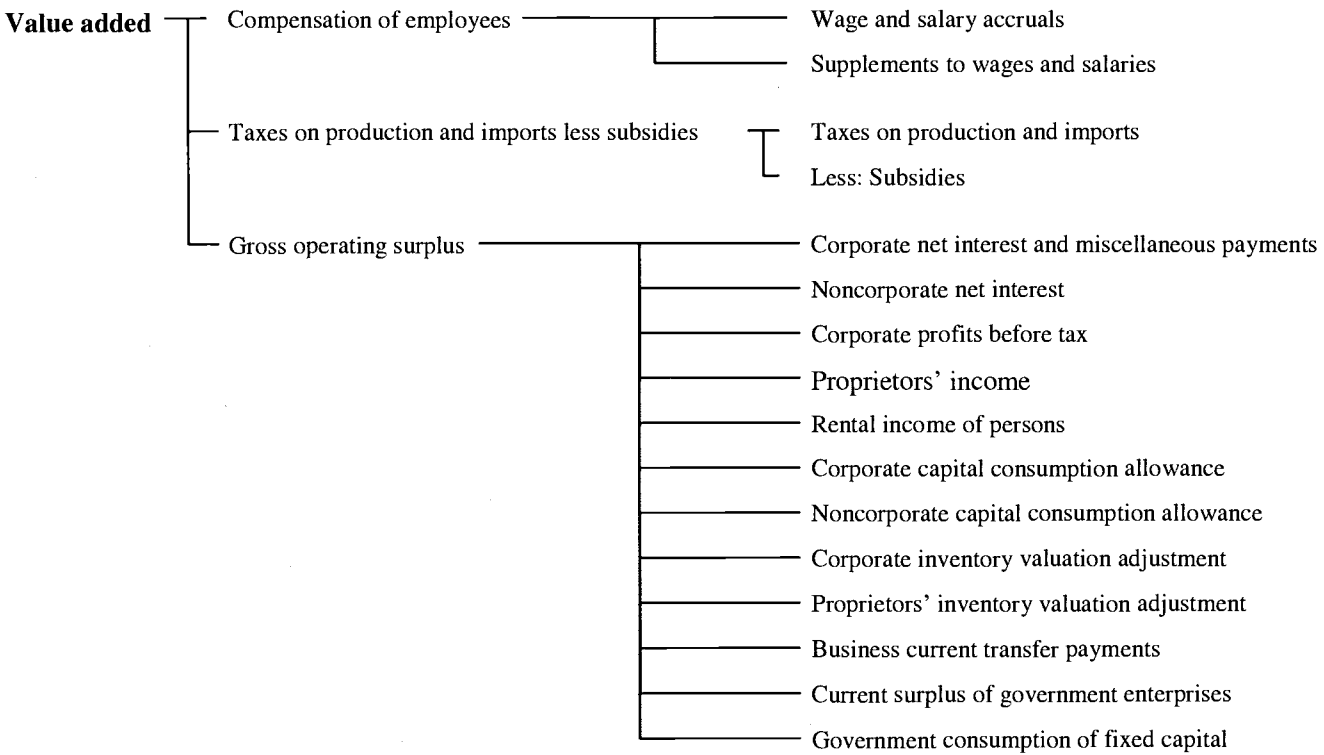


Fig. 6.2 Components of GDI-based value added by industry
Source: U.S. Bureau of Economic Analysis.

incorporates the relative strengths of both. It yields a new and improved set of annual I-O accounts and GDP-by-industry accounts that are prepared within a balanced framework and that incorporate the most timely and highest-quality source data available. It also ensures the consistency of the estimates of gross output, of intermediate inputs, and of value added by industry across the two sets of accounts.

The strength of using a balanced I-O framework is demonstrated by again referring to figure 6.1. A balanced use table ensures that the industry estimates of the I-O accounts (the column totals) are in balance with the commodity estimates of the I-O accounts (the row totals).[10] This framework tracks all of the detailed input and output flows in the economy and guarantees that each commodity that is produced is either consumed by industries as an intermediate input or is consumed by final users. An imbalance in the use table—for example, too little, or too much, supply of a commodity after intermediate inputs by industry and final uses have been accounted for—flags an inconsistency in the data. Therefore, a balanced framework provides a "consistency check" of the use table. No comparable procedure to balance industries and commodities exists for the GDP-by-industry accounts.

The strength of the GDP-by-industry methodology is that the estimates of value added by industry are derived directly from high-quality source data, so these measures generally provide better estimates of value added for industries relative to the I-O estimates. Nonetheless, several factors can affect the quality of the GDP-by-industry estimates for specific industries. For example, gross operating surplus, one component of value added by industry, includes several items—such as corporate profits before tax, corporate net interest, and corporate capital consumption allowances—that are based on corporate tax return data from the IRS. Because the consolidated tax return data of an enterprise may account for activities by several establishments classified in different industries, the BEA must convert these enterprise- or company-based data to an establishment or plant basis. The conversion can introduce errors because it is based on employment data for establishments that are cross-classified by enterprise, and because it is based on relationships from an economic census year that are likely to change over time. In addition, proprietors' income, another component of gross operating surplus, can introduce errors because the industry distributions of proprietors' income are based on incomplete source data. Industries with large shares of value added from proprietors' income are regarded as having lower-quality estimates.[11]

10. The I-O framework also includes a balanced make table, which requires that the different commodities produced by industries are consistent with total commodity and industry outputs for the economy.

11. Proprietors' income is defined here to equal the sum of NIPA estimates for proprietors' income without inventory valuation adjustment (IVA) and capital consumption adjustment

The GDP-by-industry measures of value added may be of a higher or lower quality than those from the benchmark I-O accounts, depending on the data used. For an industry with high-quality data on gross output and intermediate inputs, the measure of value added from the benchmark I-O accounts may be superior, particularly when the GDP-by-industry measure includes a large enterprise-establishment adjustment or a substantial amount of proprietors' income. Alternatively, for an industry with a small enterprise-establishment adjustment and a negligible amount of proprietors' income, the GDP-by-industry measure may be superior, particularly if the coverage of intermediate inputs in the quinquennial economic census is small for the benchmark I-O measure. For the 1997 benchmark I-O accounts, less than half of all intermediate inputs were covered by the economic census; for many industries, this results in lower-quality measures of value added. In contrast, for nonbenchmark years, the GDP-by-industry accounts always provide the preferred measures of value added, because estimates of intermediate inputs in the annual I-O accounts are currently based on very sparse data and are unable to yield high-quality measures of value added by industry.[12]

The advantages of a partial integration methodology, however, go beyond incorporating the best methods and source data from each methodology. Because the annual I-O accounts are estimated concurrently with the GDP-by-industry accounts, they are released on an accelerated schedule. The 2002 annual I-O table, published in June 2004, was released eighteen months rather than thirty-six months after the end of the reference year. In addition, in the fall of 2004, the annual I-O accounts adopted the revision schedule of the NIPAs; at that time, the revised tables for 2001 and 2002 and new tables for 2003 were released. The revised I-O estimates that are consistent with the annually revised NIPA estimates provide users with yet another level of consistency. Finally, the partial integration methodology imposes a time series consistency on the annual I-O tables, making the tables more useful for analyses of trends over time.

A further advantage of the partial integration methodology is a "feedback loop" to the NIPAs that is demonstrated by examining the relationships among the national accounts (figure 6.3). Before the integration of

(CCAdj), proprietors' net interest, proprietors' capital consumption allowance, and proprietors' IVA. The NIPA adjustment to nonfarm proprietors' income without IVA and CCAdj for misreporting on income tax returns is shown in NIPA table 7.14, "Relation of Nonfarm Proprietors' Income in the National Income and Product Accounts to Corresponding Measures as Published by the Internal Revenue Service."

12. The Bureau of the Census has recently undertaken initiatives to improve the coverage of intermediate inputs by industry in several of its annual surveys. For example, the Annual Survey of Manufactures has expanded its coverage of expenses to include purchased services by industry, and the Service Annual Survey has initiated the collection of data on expenses by industry.

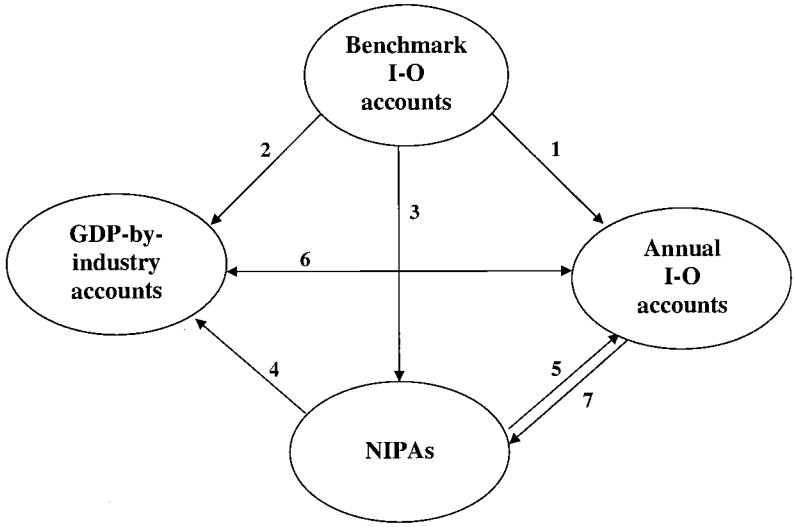


Fig. 6.3 Relationships among national economic accounts
Source: U.S. Bureau of Economic Analysis.
Notes: GDP = gross domestic product; I-O = input-output; NIPAs = National Income and Product Accounts

the annual I-O accounts and the GDP-by-industry accounts, the benchmark I-O accounts provided the following: a starting point for updating the annual I-O accounts (arrow 1), the best-level estimates of gross output to the GDP-by-industry accounts (arrow 2), and the best-level estimates and commodity splits of GDP to the NIPAs (arrow 3). The NIPAs provided estimates of GDI by industry to the GDP-by-industry accounts (arrow 4) and information on the annual composition of GDP to the annual I-O accounts (arrow 5). The partial integration results in an exchange of information between the annual I-O accounts and the GDP-by-industry accounts (arrow 6), and it also provides a feedback loop to the NIPAs (arrow 7). Because the integrated industry accounts will be prepared within a balanced framework, they will provide annual estimates of the commodity composition of GDP final expenditures that could potentially be used to improve the NIPA measures of GDP.

6.3 Full Integration: The Long-Run Goal

Integration of the annual I-O accounts and the GDP-by-industry accounts is only the first step, although a very important one, toward the BEA's long-run goal to fully integrate all components of its industry accounts, including the benchmark I-O accounts, and to integrate the in-

dustry accounts with the NIPAs. Although full integration is dependent upon continued costly investments by the federal statistical agencies to improve the coverage and consistency of their economic data, the benefits are significant in providing higher-quality information to data users. With more consistent and comprehensive data on industry inputs, the benchmark I-O accounts would provide the best measures of value added by industry for benchmark years. With updated annual information on intermediate inputs by industry, the annual I-O accounts and the GDP-by-industry accounts would provide annual updates of value added by industry that would be independent of the NIPA measures of GDP. With full integration, BEA would have a production-based measure of GDP that would provide new information to the NIPAs through the feedback loop discussed earlier (figure 6.3). That is to say, it could provide valuable insights into imbalances between the BEA's primary measure of GDP based on the final expenditures approach and its alternative measure based on income—that is, GDI.

The BEA views the underlying framework now being implemented for partial integration as able to accommodate the requirements for full integration. That being said, however, for full integration, the data needed to populate much of this framework are presently missing, particularly consistent and comprehensive data on intermediate inputs for industries. For example, less than half of the intermediate input estimates in the 1997 benchmark I-O accounts were based on high-quality, consistent data collected by the Bureau of the Census; estimates for the balance were based on fragmented information from trade associations, company annual reports, anecdotal information, and prior benchmark I-O accounts. To be reliable, a production-based estimate of GDP requires an expansion by the Census Bureau in its coverage of business expenses from less than half to 100 percent. The methods developed by the BEA to achieve partial integration in the short run are not an adequate substitute for these improvements to source data in the long run, if the goals of full integration are to be realized. To acquire this information, the BEA is working collaboratively with other statistical agencies, particularly the Bureau of the Census, to expand information collected both for its annual surveys and for its quinquennial economic census, beginning with that for 2002.

Full integration also implies greater consistency in the data provided by different statistical agencies. For example, the quality of the BEA's industry estimates can be affected by inconsistencies in the sampling frames used by the statistical agencies, as well as differences in classification and data collection and tabulation practices. Table 6.1 compares estimates of nonagricultural payroll data collected by the Bureau of the Census with wage and salary data collected by the BLS for selected industries in 1992. Industries for which comparable information was not available are excluded from the table. The comparison shows that the estimates differ by 5 percent

Table 6.1 **Comparison of Bureau of Labor Statistics (BLS) and census nonagricultural payroll data for selected private industries, 1992 (millions of dollars unless otherwise noted)**

Industry description	BLS	Census	BLS less Census	Absolute percent difference
Total	2,046,864	2,020,570	26,294	1.3
Industries with absolute difference of 10 percent or more				
Membership organizations	15,458	10,188	5,270	34.1
Tobacco products	2,103	2,534	–431	20.5
Miscellaneous repair services	8,263	9,849	–1,586	19.2
Health services	236,388	278,598	–42,210	17.9
Pipelines, except natural gas	975	821	154	15.8
Motor freight transportation and warehousing	35,536	41,070	–5,534	15.6
Leather and leather products	2,320	1,973	347	15.0
Security and commodity brokers and dealers	39,908	34,390	5,518	13.8
Oil and gas extraction	15,539	13,933	1,606	10.3
Insurance agents, brokers, and services	21,327	19,123	2,204	10.3
Nondepository credit institutions	15,007	16,509	–1,502	10.0
Industries with absolute difference of 5 to less than 10 percent				
Real estate	29,634	26,817	2,817	9.5
Textile mill products	14,801	13,531	1,270	8.6
Transportation services	8,959	8,225	734	8.2
Water transportation	5,949	5,481	468	7.9
Industrial machinery and equipment	69,749	64,588	5,161	7.4
Social services	27,508	25,565	1,943	7.1
Retail trade	268,207	249,328	18,879	7.0
Holding and other investment offices	10,313	9,626	687	6.7
Transportation equipment	74,475	69,706	4,769	6.4
Paper and allied products	24,542	23,079	1,463	6.0
Amusement and recreation services	20,816	19,612	1,204	5.8
Motion pictures	9,611	10,160	–549	5.7
Stone, clay, and glass products	15,283	14,441	842	5.5
Wholesale trade	199,687	188,780	10,907	5.5
Industries with absolute difference of less than 5 percent				
Primary metal industries	24,612	23,483	1,129	4.6
Lumber and wood products	15,345	14,669	676	4.4
Petroleum and coal products	7,568	7,246	322	4.2
Local and interurban passenger transportation	5,624	5,394	230	4.1
Rubber and miscellaneous plastics products	24,058	25,028	–970	4.0
Food and kindred products	44,712	43,032	1,680	3.8
Automotive repair, services, and parking	17,207	16,597	610	3.5
Depository institutions	59,464	57,479	1,985	3.3
Fabricated metal products	39,745	40,929	–1,184	3.0
Construction	122,135	118,600	3,535	2.9
Electric, gas, and sanitary services	40,683	39,623	1,060	2.6
Electronic and other electric equipment	52,057	50,812	1,245	2.4
Communications	48,908	47,742	1,166	2.4
Chemicals and allied products	47,911	46,835	1,076	2.2
Insurance carriers	49,457	50,559	–1,102	2.2

(continued)

Table 6.1 (continued)

Industry description	BLS	Census	BLS less Census	Absolute percent difference
Instruments and related products	35,932	36,613	–681	1.9
Apparel and other textile products	16,792	16,506	286	1.7
Legal services	40,480	39,995	485	1.2
Nonmetallic minerals, except fuels	3,291	3,265	26	0.8
Printing and publishing	43,655	43,926	–271	0.6
Business services	115,010	114,446	564	0.5
Furniture and fixtures	10,650	10,678	–28	0.3
Miscellaneous manufacturing industries	9,210	9,189	21	0.2

Note: Several industries are excluded because of differences in coverage or nondisclosure issues. These industries include metal mining, coal mining, air transportation, hotels and other lodging places, personal services, educational services, museums, art galleries and botanical gardens, membership organizations, engineering, and accounting services.

or more for about half of these industries. Although these differences do not directly affect measures of total value added, they can potentially affect the reliability of the BEA's estimates of the labor-capital splits of industry value added. The BEA envisions that it will be able to further enhance the consistency and quality of its fully integrated accounts because data-sharing initiatives should reveal the sources of these and other similar differences in source data from the various federal statistical agencies. In the case cited, the consistency between its measures of gross output by industry and compensation of employees by industry would be improved if payroll-by-industry data prepared by the Bureau of the Census and the wages and salaries data prepared by the BLS were brought into agreement by the source agencies.

At the earliest, full integration could not be attained until the 2008–10 time frame, which is when expanded data from the 2002 Economic Census will be fully incorporated into the BEA's economic accounts, beginning with the release of the 2002 benchmark I-O accounts in 2007. If limited data sharing by statistical agencies is also made viable in the interim, the BEA will be able to better identify the sources of the differences in data from other agencies such as those identified in the example presented above for the BLS and Census Bureau data. The major benefit of such data sharing would be to enhance the consistency and quality of the BEA's fully integrated economic accounts.

6.4 The Partial Integration Methodology

The methodology, including the source data and the estimating procedures that will be used for the partial integration of the annual I-O ac-

counts and the GDP-by-industry accounts, is discussed in this section.[13] The methodology is described in a sequence of five steps: (1) establishing a level of detail for both industries and commodities; (2) revising the previously published 1997 benchmark I-O accounts that will serve as a reference point for the integrated accounts; (3) developing a 1998–2002 time series for the annual estimates of value added by industry; (4) updating and balancing the annual I-O accounts for 1998–2002, incorporating the revised 1997 benchmark I-O accounts from step 2 and the 1998–2002 estimates of value added by industry from step 3; and (5) preparing price and quantity indexes for the GDP-by-industry accounts for 1998–2002.

6.4.1 Step 1: Level of Industry and Commodity Detail

The first step in integrating the annual I-O accounts and the GDP-by-industry accounts is to establish the level of detail that can be used for both sets of accounts. Table 6.2 shows this detail and the corresponding 1997 North American Industry Classification System (NAICS) industry codes. Table 6.2 no longer shows a statistical discrepancy that has traditionally appeared as an industry in the GDP-by-industry accounts. This reflects the use of a balanced framework that requires consistency between GDP measured in terms of final expenditures and in terms of value added or income. In addition, table 6.2 does not include an industry for the inventory valuation adjustment, which has traditionally been shown in the I-O accounts. In the integrated accounts, the inventory valuation adjustment is treated as a secondary product produced by industries and included in their gross output, as well as a separate commodity going to final demand. The level of detail shown in table 6.2 applies to both industries and commodities and serves as the publication level of detail. Most of the estimation procedures, however, are applied at a finer level of industry and commodity detail in order to ensure the best estimates at the publication level.

6.4.2 Step 2: Revised 1997 Benchmark I-O Accounts

The second step in the partial integration process is to revise the previously published 1997 benchmark I-O accounts, because it must provide the relationships and levels for integrating the annual I-O accounts and GDP-by-industry accounts. The necessary revisions are from two sources. First, the 1997 benchmark I-O accounts must be modified to incorporate the definitional, methodological, and statistical changes from the 2003 comprehensive revision of the NIPAs. Incorporating these changes ensures that the integrated accounts for 1998–2002 are consistent with the levels and composition of GDP in the NIPAs. The major NIPA changes and their effects on the 1997 benchmark I-O accounts are summarized in table 6.3.

Second, after the NIPA revisions are incorporated, the level and the

13. See Moyer, Planting, Fahim-Nader, et al. (2004) and Moyer, Planting, Kern, et al. (2004).

Table 6.2 Industries and commodities in the integrated accounts

1997 NAICS industries	1997 NAICS codes
Private industries	
Agriculture, forestry, fishing, and hunting	11
Farms	111, 112
Forestry, fishing, and related activities	113, 114, 115
Mining	21
Oil and gas extraction	211
Mining, except oil and gas	212
Support activities for mining	213
Utilities	22
Construction	23
Manufacturing	31, 32, 33
Durable goods	33, 321, 327
Wood products	321
Nonmetallic mineral products	327
Primary metals	331
Fabricated metal products	332
Machinery	333
Computer and electronic products	334
Electrical equipment, appliances, and components	335
Motor vehicle, bodies and trailers, and parts	3361, 3362, 3363
Other transportation equipment	3364, 3365, 3366, 3369
Furniture and related products	337
Miscellaneous manufacturing	339
Nondurable goods	31, 32 (except 321 and 327)
Food and beverage and tobacco products	311, 312
Textile mills and textile product mills	313, 314
Apparel and leather and allied products	315, 316
Paper products	322
Printing and related support activities	323
Petroleum and coal products	324
Chemical products	325
Plastics and rubber products	326
Wholesale trade	42
Retail trade	44, 45
Transportation and warehousing	48, 49
Air transportation	481
Rail transportation	482
Water transportation	483
Truck transportation	484
Transit and ground passenger transportation	485
Pipeline transportation	486
Other transportation and support activities	487, 488, 492
Warehousing and storage	493
Information	51
Publishing industries (includes software)	511
Motion picture and sound recording industries	512

Table 6.2 (continued)

1997 NAICS industries	1997 NAICS codes
Broadcasting and telecommunications	513
Information and data processing services	514
Finance and insurance	52
Federal Reserve banks, credit intermediation, and related activities	521, 522
Securities, commodity contracts, and investments	523
Insurance carriers and related activities	524
Funds, trusts, and other financial vehicles	525
Real estate and rental and leasing	53
Real estate	531
Rental and leasing services and lessors of intangible assets	532, 533
Professional, scientific, and technical services	54
Legal services	5411
Computer systems design and related services	5415
Miscellaneous professional, scientific, and technical services	5412–5414, 5416–5419
Management of companies and enterprises	55
Administrative and waste management services	56
Administrative and support services	561
Waste management and remediation services	562
Educational services	61
Health care and social assistance	62
Ambulatory health care services	621
Hospitals and nursing and residential care facilities	622, 623
Social assistance	624
Arts, entertainment, and recreation	71
Performing arts, spectator sports, museums, and related activities	711, 712
Amusements, gambling, and recreation industries	713
Accommodation and food services	72
Accommodation	721
Food services and drinking places	722
Other services, except government	81
Government	
Government total	92
Federal	n.a.
General government	n.a.
Government enterprises	n.a.
State and local	n.a.
General government	n.a.
Government enterprises	n.a.

Note: n.a. = not applicable.

Table 6.3 NIPA changes incorporated into the 1997 benchmark input-output accounts

NIPA changes	I-O components affected
Recognize the implicit services provided by property and casualty insurance companies and provide a more appropriate treatment of insured losses.	Industry and commodity gross output for insurance carriers and related activities; intermediate inputs and gross operating surplus for all industries; final uses.
Allocate a portion of the implicit services of commercial banks to borrowers.	Industry and commodity gross output for Federal Reserve banks, credit intermediation and related activities; intermediate inputs and gross operating surplus for all industries; final uses.
Redefine change in private farm inventories to include farm materials and supplies.	Intermediate inputs and gross operating surplus for the farms industry; change in private inventories.
Reclassify Indian tribal government activities from the private sector to the state and local government sector.	Gross output, intermediate inputs, and value added for the amusements, gambling, and recreation; accommodation; and state and local government enterprises industries; state and local general government.
Reclassify military grants-in-kind as exports.	Federal general government; exports.
Recognize explicitly the services produced by general government and treat government purchases of goods and services as intermediate inputs.	Gross output and intermediate inputs for the state and local general government and Federal general government industries.
Reclassify business nontax liability as current transfer payments to government and as rent and royalties to government.	Taxes on production and imports, less subsidies and gross operating surplus for all industries; gross output for the rental and leasing services and lessors of intangible assets industry; purchases of the rental and leasing services and lessors of intangible assets commodity by selected industries.

Note: NIPAs = national income and product accounts; I-O = input-output. For details of NIPA changes, see Moulton and Seskin (2003).

composition of value added for each industry must be further modified on the basis of information from both the I-O accounts and the GDP-by-industry accounts.[14] As discussed above, value added by industry in the I-O accounts is computed as the difference between gross output and intermediate inputs by industry, and value added by industry in the GDP-by-industry accounts is computed from the industry distributions of GDI from the NIPAs. In general, these two measures of value added for an industry will differ (see the first two columns of table 6.4).[15]

14. The GDP-by-industry value added that is based on the NIPA GDI estimates will also incorporate the results from the 2003 comprehensive NIPA revision.

15. Research indicates that the magnitude and sign of these differences vary across industries and across time. For example, using data for 1992, Yuskavage (2000) finds that the

Figure 6.4 shows a matrix that demonstrates how the quality of the value added by industry estimates varies across the benchmark I-O accounts and the GDP-by-industry accounts. For example, both the benchmark I-O accounts and the GDP-by-industry accounts provide good measures of value added for the health care industry because of the near-complete coverage of gross output and intermediate inputs by the economic census and the relatively small amount of redistributions of income resulting from enterprise-establishment adjustments. On the other hand, both sets of accounts provide poor measures for the construction industry because of incomplete coverage in the economic census and because of large lower-quality, enterprise-establishment adjustments. For many industries, the quality of industry value added is mixed. Mining value added, for example, is good in the benchmark I-O accounts because of near-complete industry coverage, yet poor in the GDP-by-industry accounts because of relatively very large enterprise-establishment adjustments. The partial integration methodology draws the best information from both sets of accounts into a single "combined" estimate of value added for each industry. These combined measures are then incorporated into the 1997 benchmark I-O accounts.[16]

The combined value added for an industry is an average with weights determined by criteria that reflect the relative quality of value added from the two sets of accounts. In general, these criteria are based on the quality of the source data used for each. The criteria for the benchmark I-O accounts include the following:

- the percent of intermediate inputs by industry that are covered by source data from the quinquennial economic census
- the percent of an industry's total gross output that is accounted for by the quinquennial economic census.

The criteria for the GDP-by-industry accounts include the following:

- the quality and the size of adjustments used to convert the enterprise-based, profit-type income data to an establishment basis
- the percent of an industry's value added that is accounted for by proprietors' income

property-type income for the manufacturing sector is, on average, lower in the GDP-by-industry accounts than in the benchmark I-O accounts. However, more recent research, using data for 1997, finds that the reverse is true; for the manufacturing sector, the gross operating surplus from the GDP-by-industry accounts is, on average, larger than the gross operating surplus from benchmark I-O accounts. The BEA is continuing its research into the sources of these differences.

16. The estimates of "compensation of employees" and "taxes on production and imports, less subsidies" in the revised 1997 benchmark I-O accounts are consistent with those published in the NIPAs. For census-covered industries, the compensation in the previously published 1997 benchmark I-O accounts was based on the 1997 Economic Census. See Lawson et al. (2002), p. 31.

Table 6.4 1997 industry value added estimates

Industry	Revised benchmark I-O accounts	GDP-by-industry accounts	Combined
Farms	88,142	88,142	88,142
Forestry, fishing, and related activities	21,110	23,771	22,595
Oil and gas extraction	48,084	59,236	52,902
Mining, except oil and gas	25,869	27,854	26,414
Support activities for mining	11,941	18,439	13,333
Utilities	162,264	180,852	180,289
Construction	310,029	346,223	337,558
Wood products	26,207	30,666	28,008
Nonmetallic mineral products	40,720	37,829	40,708
Primary metals	43,799	51,214	48,337
Fabricated metal products	114,396	102,625	108,119
Machinery	104,664	88,649	98,164
Computer and electronic products	178,019	144,110	154,403
Electrical equipment, appliances, and components	41,230	79,140	45,596
Motor vehicle, bodies and trailers, and parts	93,396	117,083	103,195
Other transportation equipment	55,538	52,444	54,418
Furniture and related products	28,181	25,568	27,060
Miscellaneous manufacturing	47,861	47,793	47,729
Food and beverage and tobacco products	158,928	130,224	135,357
Textile mills and textile product mills	26,012	27,829	26,996
Apparel and leather and allied products	28,918	26,249	27,186
Paper products	51,046	51,354	51,484
Printing and related support activities	42,725	47,362	44,667
Petroleum and coal products	22,595	67,926	27,116
Chemical products	149,879	150,776	150,846
Plastics and rubber products	62,402	49,828	60,704
Wholesale trade	487,913	531,865	521,250
Retail trade	517,499	588,270	574,192
Air transportation	45,285	55,017	49,457
Rail transportation	23,133	22,590	23,030
Water transportation	7,162	6,273	6,510
Truck transportation	87,016	76,343	80,524
Transit and ground passenger transportation	17,090	12,164	12,978
Pipeline transportation	9,227	8,095	8,774
Other transportation and support activities	50,523	59,586	55,032
Warehousing and storage	19,014	20,003	19,549
Publishing industries (includes software)	114,475	65,572	87,457
Motion picture and sound recording industries	25,272	22,899	24,298
Broadcasting and telecommunications	196,395	212,151	208,862
Information and data processing services	30,418	18,550	27,189
Federal Reserve banks, credit intermediation, and related activities	274,457	251,974	259,541
Securities, commodity contracts, and investments	107,598	131,109	119,470
Insurance carriers and related activities	175,610	217,464	206,566
Funds, trusts, and other financial vehicles	9,957	9,882	9,965
Real estate	944,801	886,560	908,544
Rental and leasing services and lessors of intangible assets	118,401	74,444	89,854

Table 6.4 (continued)

Industry	Revised benchmark I-O accounts	GDP by industry accounts	Combined
Legal services	111,052	119,435	114,460
Computer systems design and related services	69,536	87,477	78,642
Miscellaneous professional, scientific, and technical services	343,445	308,416	325,057
Management of companies and enterprises	145,665	145,665	145,665
Administrative and support services	228,861	197,921	211,363
Waste management and remediation services	22,618	20,339	21,372
Educational services	63,371	61,295	62,240
Ambulatory health care services	267,784	261,920	267,232
Hospitals and nursing and residential care facilities	205,830	199,526	203,543
Social assistance	38,834	43,181	40,065
Performing arts, spectator sports, museums, and related activities	30,050	34,717	32,911
Amusements, gambling, and recreation industries	45,180	37,667	41,133
Accommodation	75,769	71,018	74,689
Food services and drinking places	151,890	133,183	141,062
Other services, except government	206,147	185,476	197,403

For both the benchmark I-O accounts and the GDP-by-industry accounts, these criteria, along with expert analyst judgment, are applied at the industry level shown in table 6.2 in order to identify point estimates and estimates of variance for each industry's measure of value added.[17] These point estimates and estimates of variance are used to develop a probability distribution of value added for each industry from each set of accounts. Each probability distribution represents a measure of the likelihood that the "true" value added takes on a particular value, given the information available. The distributions are then combined to produce a measure of value added for each industry. Essentially, the combined measure is an average of the two point estimates with the weights being determined by the relative variances—that is, a point estimate with a smaller variance receives a larger weight. Appendix A provides technical details on the procedures used.

Figure 6.5 gives an example of this process for the educational services industry. The point estimate of value added is $63.4 billion from the revised 1997 benchmark I-O accounts and $61.3 billion from the GDP-by-

17. The estimates are prepared at this level of detail because the industry distributions of GDI are available at this level. These estimates are allocated to more detailed industries when the revised benchmark I-O table is balanced. Source data for 1997 were not available on the 1997 NAICS basis for all of the components of GDI. For selected components, the BEA converted data from the 1987 Standard Industrial Classification (SIC) basis to the 1997 NAICS basis.

GDP-by-Industry Value Added	Benchmark Value Added: Good Benchmark data/ good GDP-by-industry data e.g., Health care	Benchmark Value Added: Good Benchmark data/ poor GDP-by-industry data e.g., Mining
	Poor Benchmark data/ Good GDP-by-industry data e.g., Transportation/ Warehousing	Poor Benchmark data/ poor GDP-by-industry data e.g. Construction

Fig. 6.4 Merging information for setting value-added levels
Source: U.S. Bureau of Economic Analysis.

industry accounts. The benchmark I-O value-added estimate reflects only a limited amount of information on this industry's gross output and intermediate inputs, because most establishments classified in this industry are out of the scope of the quinquennial economic census. Therefore, the information used to prepare the I-O estimates was drawn from a variety of sources, including trade association data. The quality of these data is not as high as data from the economic census. In contrast, the GDP-by-industry value-added estimate reflects relatively complete data, based on the industry distributions of GDI from the NIPAs. Nevertheless, examining the two quality criteria for the GDP-by-industry accounts reveals that proprietors' income for this industry is about 3 percent of total value added and that the amount of adjustment required to convert enterprise-based profit-type income data to an establishment basis is about 1 percent. This implies that the combined estimate should be close, but not equal to, the GDP-by-industry point estimate.

A more formal analysis of the educational services industry is shown in figure 6.5, which includes the related probability distributions for each of the two point estimates. Note that the GDP-by-industry distribution is more peaked (smaller variance) than the distribution from the I-O accounts (larger variance). The smaller variance reflects a relatively good GDP-by-industry estimate; the larger variance for the benchmark I-O accounts reflects a relatively lower-quality estimate. As expected, the combined estimate of $62.2 billion is closer to the GDP-by-industry estimate than to the I-O estimate; the GDP-by-industry estimate is given a weight of about 57 percent, while the I-O estimate is given a weight of about 43 percent. Because more information is used to make this combined estimate, its overall quality is higher than that for either of the individual estimates, as shown by their distributions in figure 6.5. A complete list of the

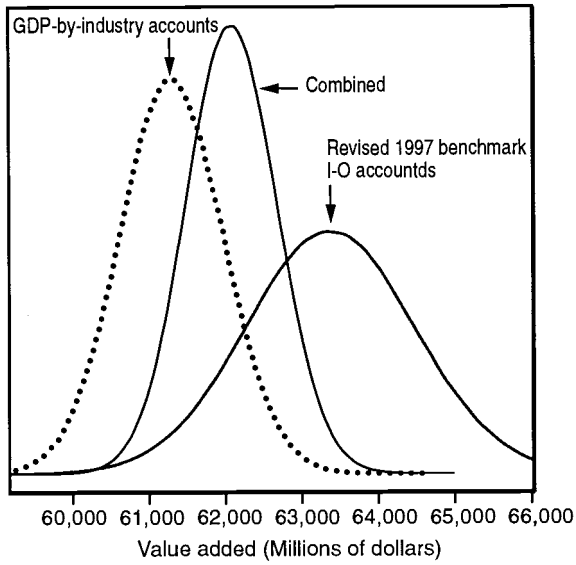


Fig. 6.5 Probability distributions of value added for educational services
Source: U.S. Bureau of Economic Analysis.

combined estimates of value added by industry is shown in the third column of table 6.4.

After the two sets of revisions have been made to the 1997 benchmark I-O accounts, it is then balanced. For this balancing, each industry's gross output and new measure of value added are fixed, and its total of intermediate inputs is allowed to adjust to the difference. Balancing ensures that the use of commodities equals their supply, the sum of each industry's value added and intermediate inputs equals its gross output, and the sum of final uses equals published GDP. The revised and balanced 1997 benchmark I-O accounts then provide a starting point for preparing the integrated accounts for 1998–2002.

6.4.3 Step 3: A Time Series of Value Added for 1998–2002

A time series of value added by industry is prepared by extrapolating the revised 1997 benchmark I-O estimates of value added by industry forward to 1998–2002, using the GDI-based measure of value added from the GDP-by-industry accounts as the extrapolator for each industry. The integrated industry accounts for 1998–2002 are presented on the 1997 NAICS basis.[18] The components of GDI that compose value added by industry and

18. On November 9, 2005, the BEA published the NAICS-based GDP-by-industry estimates for years 1947–86.

information on the major source data and on the industrial distribution for each component are shown in table 6.5.

As discussed above, the quality of the GDI-based measures of value added depends on a number of factors, including the size of adjustments required to convert enterprise-based, profit-type GDI data to an establishment basis and the size of proprietors' income. Nonetheless, they are preferred as growth indicators when compared with those from the annual I-O residual methodology because of the scarcity of annual data on intermediate inputs for credible measures of value added.

After extrapolating the revised 1997 benchmark I-O level of value added forward with the GDI-based measure for each industry, the resulting sum of value added across industries will not necessarily sum to GDP in a given year—part of the difference being the statistical discrepancy and the other part being extrapolation errors.[19] This procedure allocates this difference in two steps. In the first step, expert analyst judgment is used to adjust some industries with known measurement problems. In the second step, the remaining difference is distributed across industries in proportion to the industries' value added.

6.4.4 Step 4: Updated and Balanced Annual I-O Accounts for 1998–2002

Five tasks must be completed sequentially to update and balance each of the five annual I-O tables for 1998–2002. These tasks are (a) estimating gross output for each industry and commodity; (b) estimating the commodity composition of intermediate inputs for each industry; (c) estimating the domestic supply for each commodity; (d) incorporating estimates of commodities used for personal consumption, for gross private fixed investment, and for government consumption and investment as part of GDP final-demand expenditures; and (e) balancing the use of commodities with available supply and the output of industries with necessary inputs for production.

Industry and Commodity Gross Output

For most industries and commodities, annual source data are available to estimate current-year industry and commodity gross output. The data sources used are shown in table 6.6. Manufacturing, trade, and most service industry estimates are based on annual survey data from the Bureau of the Census. Agriculture, insurance, and government enterprise estimates, as well as transportation, utilities, finance, and real estate estimates,

19. The BEA also investigated using gross output by industry as an extrapolator for the revised 1997 benchmark I-O value added. This procedure—which assumes industry input-output ratios are constant over time—was not adopted, because tests on historical data showed that it yields larger discrepancies between the sum of extrapolated value added and GDP relative to GDI extrapolation.

Table 6.5 Principal source data for value-added extrapolators

Component of gross domestic income	Major source data	Industrial distribution	
		Distribution available in source data	Data or asusmption used if distribution by establishment is not available in source data
	Compensation of employees, paid		
Wages and salary accruals[a]	BLS tabulations of wages and salaries of employees covered by state UI programs and OPM data on wages and salaries of Federal Government employees.	Establishment	
Supplements to wages and salaries			
Employer contributions for employee pension and insurance funds	DOL tabulations of IRS data (Form 5500) on pension plans, HHS data from the Medical Expenditure Panel Survey on health insurance, and trade association data for other types.	None[b]	BLS employer cost index and UI tabulations.
Employer contributions for government social insurance	Federal budget data.	None	Social Security Administration and BLS tabulations.
	Taxes on production and imports less subsidies		
Taxes on production and imports	Federal budget data and Census Bureau data on state and local governments.	None	Property taxes are based on BEA capital stock distribution.
Subsidies	Federal budget data and Census Bureau data on state and local governments.	None	Payments are assigned to the industries being supported.

(continued)

Table 6.5 (continued)

Component of gross domestic income	Major source data	Industrial distribution	
		Distribution available in source data	Data or asusmption used if distribution by establishment is not available in source data
	Gross operating surplus		
Private enterprises			
Net interest and miscellaneous payments, domestic industries			
Corporate	IRS tabulations of data from corporate tax returns (Form 1120 series), FFIEC Call Report data on commercial banks, trade association data on life insurance companies.	Company	Census Bureau company-establishment employment matrix.
Noncorporate	IRS tabulations of tax return data from sole proprietorships (Form 1040 Schedule C) and partnerships (Form 1065), FRB flow-of-funds-account data on residential mortgages.	Company	Assumed to be equivalent to an establishment distribution.
Business current transfer payments (net)	IRS tabulations of data from corporate tax returns (Form 1120 series), trade association data for property-casualty insurance net settlements and for other types.	Company	Industry-specific payments are assigned to those industries; others are based on IRS company industry distribution.
Proprietors' income with IVA and without CCAdj			
Farm	USDA farm income statistics.	Establishment	
Nonfarm			
Proprietors' income without IVA and CCAdj	IRS tabulations of tax return data from sole proprietorships (Form 1040 Schedule C) and partnerships (Form 1065).	Company	Assumed to be equivalent to an establishment distribution.
IVA	BLS prices and IRS inventory data.	Establishment	

Rental income of persons without CCAdj	Census Bureau data on housing units and rents from the American Housing Survey, HMDA data on residential mortgages, and IRS tabulations of data from individual tax returns (Form 1040).	Establishment	
Corporate profits before tax with IVA and without CCAdj, domestic industries			
Corporate profits before tax without IVA and CCAdj	IRS tabulations of data from corporate tax returns (Form 1120 series) and regulatory agencies and public financial reports data.	Company	Census Bureau company-establishment employment matrix.
IVA	BLS prices and IRS inventory data	Establishment	
Capital consumption allowances			
Corporate	IRS tabulations of data from corporate tax returns (Form 1120 series).	Company	Census Bureau company-establishment employment matrix.
Noncorporate	IRS tabulations of tax return data from sole proprietorships (Form 1040 Schedule C) and partnerships (Form 1065).	Company	Assumed to be equivalent to an establishment distribution.
Current surplus of government enterprises	Federal budget data and Census Bureau data on state and local governments.	Establishment	
Consumption of fixed capital			
Households and institutions[c]	BEA capital stock estimates.	Establishment	
Government	BEA capital stock estimates.	Type of agency	

Notes: BEA = Bureau of Economic Analysis; BLS = Bureau of Labor Statistics; CCAdj = Capital consumption adjustment; DOL = Department of Labor; FFIEC = Federal Financial Institutions Examination Council; FRB = Federal Reserve Board of Governors; HCFA = Health Care Financing Administration; HHS = Department of Health and Human Services; HMDA = Home Mortgage Disclosure Act; IRS = Internal Revenue Service; IVA = Inventory valuation adjustment; OPM = Office of Personnel Management; UI = Unemployment insurance; USDA = U.S. Department of Agriculture.

[a]Includes wage and salary disbursements to the rest of the world and excludes wages and salaries received from the rest of the world.

[b]A company-based industrial distribution for pension plans is available in the source data.

[c]Consists of owner-occupied housing and nonprofit institutions primarily serving households.

Table 6.6 Principal sources of data for industry and commodity output and prices

Industry and commodity	Source data for extrapolator	Source data for price index
Agriculture, forestry, fishing and hunting		
Farms	USDA cash receipts from marketing and inventory change	USDA prices received by farmers; PPI
Forestry, fishing, and related activities	For forestry, Census Bureau shipments; for fishing, NOAA value of fish landings; for related activities, NIPA estimates	PPI; NOAA; NIPA deflator
Mining		
Oil and gas extraction	DOE quantity produced and prices	For crude petroleum and natural gas, IPD from DOE; for natural gas liquids, PPI
Mining, except oil and gas	DOE quantity produced and average price for uranium and coal; USGS quantity and price data for all others	IPD from DOE and USGS
Support activities for mining	DOE, USGS, and trade sources for quantity produced and prices	IPD from DOE, USGS and trade sources; for exploration, PPI
Utilities		
Electric utilities	EIA	PPI
Natural gas	EIA quantity and price data	PPI
Water, sewage, and other systems	PCE	CPI
Construction		
For the Department of Defense	DOD expenditures data	DOD prices for military construction; cost indexes from trade sources and government agencies for other construction
For state and local highways	Census Bureau data from the ASGF	Cost indexes from government agencies
For private electric and gas utilities	Federal regulatory agencies and trade sources expenditures data	Cost indexes from trade sources and government agencies
For farms, excluding residential	USDA expenditures data	Trade sources cost index; Census Bureau price deflator for new single-family houses under construction
For other nonresidential	Census Bureau data on value of construction put in place	Trade sources and government agency cost indexes; Census Bureau price index for new single-family houses under construction; BEA quality-adjusted price indexes for factories, office buildings, warehouses, and schools

For other residential	Census Bureau data on value of construction put in place	Census Bureau price index for new single-family houses under construction; BEA price index for multifamily construction
Manufacturing	Census Bureau data on shipments and inventory change	PPI; quality-adjusted price indexes for computers, photocopying equipment, digital telephone switching equipment, and LAN equipment; BEA price indexes based on DOD prices paid for military equipment
Wholesale trade	Census Bureau ATS data	Sales price by kind-of-business computed from PPI
Retail trade	Census Bureau ARTS data	Sales price by kind-of-business computed from CPI
Transportation and warehousing		
Air transportation	BTS Air Carrier Financial Statistics	IPD for total passenger-related revenues and passenger miles from DOT; IPD for total freight-, mail-, and express-related revenues and ton miles from DOT; wages and salaries per employee from BLS
Rail transportation	Amtrak and trade sources	PPI
Water transportation	Army Corps of Engineers; trade sources	PPI for freight; for passengers, CPI
Truck transportation	Census Bureau SAS	PPI
Transit and ground passenger transportation	PCE; BTS	For taxicabs, intercity buses, and other local transit, PCE price index; for school buses, BLS data on wages and salaries per employee
Pipeline transportation	Trade sources	PPI
Other transportation and support activities	PCE	For sightseeing, PCE price index; for other transportation and support activities, PCE price indexes and PPI
Warehousing and Storage	Census Bureau SAS	PPI
Information		
Publishing industries (includes software)	Census Bureau SAS	BEA price indexes for prepackaged and custom software for software publishers; for all other publishing industries, PPI

(continued)

Table 6.6 (continued)

Industry and commodity	Source data for extrapolator	Source data for price index
Motion picture and sound recording industries	Census Bureau SAS	PCE price indexes
Broadcasting and telecommunications	Census Bureau SAS	For cable networks, programming, and telecommunications, PPI; for radio and television broadcasting, network receipts, and all other telecommunications, composite price index of PPIs
Information and data processing services	Census Bureau SAS	For information services,PCE price indexes; for data processing services, PPI
Finance and insurance		
Federal Reserve banks, credit intermediation, and related activities	FDIC; FRB; NIPA imputed service charges; NCUA; and other private agencies	PCE price indexes; other government data
Securities, commodity contracts, investments	SEC FOCUS Report	PCE price indexes
Insurance carriers and related activities	Trade sources for insurance carriers; BEA estimates for property and casualty insurance; for all other insurance, PCE; for insurance agents, brokers, and services, IRS tabulations of business tax returns	For health and life insurance, PCE price indexes; for property and casualty insurance, PPI; for agents,brokers, and services, composite price index based on trade sources data and PCE price indexes
Funds, trusts, and other financial vehicles	NIPA imputed service charges for other financial institutions; EBSA data on pension funds	IPD from NIPA imputed service charges; composite price index based on PCE price indexes; PPI data; BLS data on wages and salaries per full-time employee
Real estate and rental and leasing		
Real estate	For residential dwellings and real estate agents and managers, NIPA housing data; for nonresidential dwellings, IRS tabulations of business tax returns; NIPA rental value of buildings owned by nonprofits	For nonfarm residential dwellings, NIPA price index; for nonresidential dwellings, PPI; for real estate managers and agents, PPI and trade sources; IPD for nonprofit and farm residential dwellings

Rental and leasing services and lessors of intangible assets	For rental and leasing services, Census Bureau SAS; for royalties, IRS tabulations of business tax returns	For automotive equipment rental, PPI; for other rental services, PCE price indexes; for royalties, PCE price index and IPD from DOE and PPI
Professional, scientific, and technical services		
Legal services	Census Bureau SAS	PPI
Computer systems design and related services	Census Bureau SAS	BEA price indexes for prepackaged and custom software
Miscellaneous professional, scientific and technical services	Census Bureau SAS	PPI; BLS wages and salaries per full-time employee
Management of companies and enterprises	BLS wages and salaries	BLS wages and salaries per full-time employee
Administrative and waste management services		
Administrative and support services	Census Bureau SAS	BLS wages and salaries per full-time employee; PCE price indexes; PPI
Waste management and remediation services	Census Bureau SAS	CPI
Educational services	PCE	PCE price index based on trade sources
Health care and social assistance		
Ambulatory health care services	Census Bureau SAS	PPI; PCE price indexes
Hospitals and nursing and residential care facilities	Census Bureau SAS	PCE price indexes
Social assistance	Census Bureau SAS	PCE price indexes
Arts, entertainment, and recreation		
Performing arts, spectator sports, museums, and related activities	Census Bureau SAS	PCE price indexes

(continued)

Table 6.6 (continued)

Industry and commodity	Source data for extrapolator	Source data for price index
Amusements, gambling, and recreation industries	Census Bureau SAS	PCE price indexes
Accommodation and food services		
Accommodation	Census Bureau ARTS	For hotels and motels, PPI; PCE price index
Food services and drinking places	Census Bureau ARTS	CPI
Other services except government	For religious, labor, and political organizations, PCE; for other services, Census Bureau SAS; for private households, BEA compensation of employees	CPI; BLS data on wages and salaries per full-time employee; PCE price indexes
Government		
Federal		
General government	NIPA estimates	NIPA price indexes
Government enterprises	USPS receipts; for electric utilities, DOE; other government data	For USPS and electric utilities, PPI; for all others, PCE price index and NIPA price indexes
State and local		
General government	NIPA estimates	NIPA price indexes
Government enterprises	For electric utilities, DOE data; for other enterprises, BEA data on revenue by type	PPI

Notes: ARTS = Annual Retail Trade Survey, Census Bureau; ASGF = Annual Survey of Government Finances, Census Bureau; ATS = Annual Trade Survey, Census Bureau; BEA = Bureau of Economic Analysis; BLS = Bureau of Labor Statistics; BTS = Bureau of Transportation Statistics; CPI = Consumer Price Index, BLS; DOC = Department of Commerce; DOD = Department of Defense; DOE = Department of Energy; DOT = Department of Transportation; EBSA = Employee Benefits Security Administration; EIA = Energy Information Administration; FDIC = Federal Deposit Insurance Corporation; FOCUS = Financial and Operational Combined Uniform Single Report, SEC; FRB = Federal Reserve Board of Governors; IPD = Implicit price deflator; IRS = Internal Revenue Service; NCUA = National Credit Union Association; NIPA = National income and product accounts, BEA; NOAA = National Oceanic and Atmospheric Administration; PCE = Personal consumption expenditures, BEA; PPI = Producer Price Index, BLS; SAS = Service Annual Survey; SEC = Securities and Exchange Commission; USDA = U.S. Department of Agriculture; USGS = U.S. Geological Survey, Office of Minerals; USPS = U.S. Postal Service.

are primarily based on data from other government statistical agencies and private sources. For those industries and commodities for which annual source data are not available at the 1997 benchmark I-O level of detail, more aggregated source data are used as extrapolators.

Intermediate Inputs to Industries

Industry inputs are estimated in three steps. First, for domestic inputs, each industry's current-year output is valued in terms of the previous year's prices, using an industry price index that is calculated—in a Fisher index-number formula—as a weighted average of the price indexes for commodities produced by the industry. Estimates of inputs from foreign sources are revalued using import price indexes. For commodities for which a price index is unavailable, an aggregate price index is applied to multiple commodities. The data sources used to prepare these indexes are shown in table 6.6.

Second, each industry's current-year output, valued in the prices for the previous year, is multiplied by the previous year's direct requirements coefficient for the same industry. The initial set of coefficients used are from the revised 1997 benchmark I-O accounts. The result of this multiplication yields current-year intermediate inputs valued in the prices of the previous year.[20] At this point, the composition of an industry's inputs per dollar of output (valued in the prices of the previous year) is unchanged from that of the previous year. To adjust for changes in relative prices, the results are reflated to current-year prices, using the commodity price indexes.

Finally, commodity taxes, transportation costs, and trade margins for each intermediate input are estimated. Commodity taxes are added to increase the value of intermediate inputs from basic prices to producers' prices, and transportation costs and trade margins are added to increase the value further to purchasers' prices.[21] Estimates for commodity taxes and total transportation costs and margins are developed as part of the annual estimates of commodity gross output and are distributed to transactions using 1997 benchmark I-O relationships.

Domestic Supply

The domestic supply is estimated. The domestic supply of each commodity is the total value of goods and services available for consumption as intermediate inputs by industries or for final use as personal consumption, private fixed investment, and government consumption and gross investment. It is calculated as domestic commodity output, plus government sales, and imports less exports and change in private inventories. Imports and exports are based on foreign trade statistics from the Bureau of the

20. A direct requirements coefficient represents the amount of a commodity required by an industry to produce a dollar of the industry's output.

21. The basic price is the price received by the producer for goods sold; it excludes the taxes collected by the producer from purchasers, as well as transportation costs and trade margins.

Census and on the BEA's international transactions accounts. Changes in private inventories are from the NIPAs, and the commodity composition of inventories held by industries is based on relationships from the revised 1997 benchmark I-O accounts.

Commodity Composition of Final Uses Excluding Imports and Exports and Changes in Private Inventories

The annual estimates of the major expenditure components of final uses for personal consumption, private fixed investment, and government consumption and gross investment are obtained directly from the NIPAs. The initial commodity compositions of these components are estimated using relationships from the revised 1997 benchmark I-O accounts.

Balancing the Use Table

Finally, commodities and industries are brought into balance using a biproportional adjustment procedure. This procedure sequentially adjusts rows and columns to equal the estimated output control totals. The adjustments are made iteratively until the use of each commodity equals its domestic supply, the sum of value added and intermediate inputs for each industry equals its gross output, and final-demand expenditures equal levels in the NIPAs. Unlike many I-O balancing systems, the system employed for the annual I-O tables takes advantage of the very detailed relationships included in the 1997 benchmark I-O accounts and balances in both producers' and purchasers' prices. The system balances approximately 3,000 rows and 1,200 columns while maintaining information on transportation costs and margins for each transaction. Appendix B provides a more detailed discussion of the techniques used for this balancing.

The annual I-O accounts are finalized for 1998–2002 after the results have been reviewed and verified. The measures of gross output, intermediate inputs, and value added by industry are then incorporated into the GDP-by-industry accounts.

6.4.5 Step 5: Price and Quantity Indexes for the GDP-by-Industry Accounts

Price and quantity indexes for the GDP-by-industry accounts are prepared in two steps. First, price and quantity indexes for gross output and intermediate inputs are prepared for each industry. Second, information on gross output by industry is combined with information on intermediate inputs by industry to derive price and quantity indexes for value added by industry, using the double-deflation procedure.

Indexes for Gross Output and Intermediate Inputs by Industry

Price and quantity indexes for gross output by industry are derived by separately deflating each commodity produced by an industry and included in its gross output. Information on the commodities produced by

industries is obtained from annual I-O make tables. Price and quantity indexes for intermediate inputs are estimated by deflating the commodities used by industries from the annual I-O use tables. The commodity price indexes used for this deflation are listed in table 6.6. When a commodity price index is based on more than one detailed price index, a Fisher index-number formula is used to prepare the composite index. Appendix C, "Computing Chain-Type Price and Quantity Indexes in the GDP-by-Industry Accounts," shows the Fisher index-number formulas that are used to prepare the price and quantity indexes for gross output and intermediate inputs by industry.

Indexes for Value Added by Industry

Price and quantity indexes for value added by industry are calculated using the double-deflation method. In the double-deflation method, separate estimates of gross output and intermediate inputs by industry are combined in a Fisher index-number formula in order to generate price and quantity indexes for value added by industry (see appendix C). This method is preferred for computing price and quantity indexes for value added by industry because it requires the fewest assumptions about the relationships among gross outputs.

6.5 Future Research

There are several areas of research that must be addressed in order to achieve the BEA's long-run goal of full integration of the accounts. The most important of these are the following:

- Additional evaluation of the coverage, quality, and consistency of data from different sources for the purpose of improving the BEA's industry accounts overall and its estimates of value added by industry specifically. This includes working cooperatively with other statistical agencies for the purpose of collecting additional data as well as expanding data-sharing initiatives to address differences across alternative data sources.
- Related research to determine the underlying reasons for the discrepancies that existed between the GDP-by-industry and I-O levels of value added prior to setting a "combined" level for the integrated accounts. The fact that these discrepancies were clearly evident prior to the integration indicates underlying inconsistencies in source data and methodologies that need to be explored further. This research will also require working cooperatively with the statistical agencies providing the source data.
- Continued research to develop new methods and data sources that improve measures of gross operating surplus and direct measures of value added by industry that are consistent with establishment-based

definitions for industries. This is in contrast to the method of estimating value added as a residual resulting from intermediate purchases being subtracted from gross output. Although this method results in consistent estimates, it also picks up statistical errors that do not have anything to do with value added.

- Development of additional procedures to incorporate new data from the 2002 Economic Census and annual surveys of intermediate inputs by industry into the BEA's industry accounts on a more accelerated basis, including techniques for evaluating "best-level" estimates as compared to "best-change" estimates.
- Development of new processes and procedures for incorporating information from the production-based approach of measuring GDP into the NIPAs on a timely basis.
- Extension of the NAICS-based industry accounts backward for years prior to 1998.[22] Research is needed to develop current-dollar annual I-O tables for years prior to 1998.

Appendix A

Estimating the "Combined" Level of Value Added by Industry

This appendix describes the procedure used to determine the "combined" estimates of value added by industry that are incorporated into the revised 1997 benchmark I-O accounts. The procedure allows for the best information from both the I-O accounts and the GDP-by-industry accounts to be used in determining the combined estimates. This is accomplished by preparing a weighted average of the two independent measures of value added where the weights reflect the relative quality of the two measures. For each of the sixty-one industries presented in table 6.4, a weighted average is given by

$$\text{Combined}_i = b_{i,\text{I-O}}(\text{I-O}_i) + b_{i,\text{GDP by Industry}}(\text{GDP by Industry}_i),$$

where (I-O_i) is industry i's point estimate of value added from the benchmark I-O accounts and $(\text{GDP by Industry}_i)$ is industry i's point estimate from the GDP-by-industry accounts. $b_{i,\text{I-O}}$ and $b_{i,\text{GDP by Industry}}$ are the weights for the benchmark I-O accounts and the GDP-by-industry accounts, respectively.

In this linear combination, the weights are a simple function of the rela-

22. In November 2004 and November 2005, the BEA published the NAICS-based GDP-by-industry accounts for the periods 1987–97 and 1947–86, respectively. See Yuskavage and Pho (2004) and Yuskavage and Fahim-Nader (2005).

tive precision of each point estimate. A modeling framework is developed to estimate the precision of each industry's value-added estimator. The precision of each point estimate is summarized using two measures. First, an ordinal quality ranking of industries is developed for both the benchmark I-O accounts and the GDP-by-industry accounts. Second, an approximate 95 percent confidence interval for each point estimate is determined by evaluating the uncertainty in the underlying source data. Implicit in both the ordinal ranking and the confidence intervals are the quality criteria outlined in section 6.4.2 (step 2) of the main text. A review of these criteria suggests that a significant amount of expert analyst judgment is incorporated into this framework.

Two practical considerations constrained the modeling framework finally selected by the BEA for estimating weights. First, the overall objective is to obtain the most accurate weighted average feasible from the information currently available. Second, the model must not be overly sensitive to misspecifications of the 95 percent confidence intervals.

The chosen model requires the following assumptions:

1. Information about each benchmark I-O and GDP-by-industry value-added estimate can be effectively summarized by estimating the mean and standard deviation of a normal distribution. (This assumption implies that the standard deviation accurately summarizes the uncertainty associated with each estimator.)
2. The relative quality of the estimates from the benchmark I-O accounts and the GDP-by-industry accounts can be evaluated based on their ratios of point estimate to standard deviation.
3. The point estimate–standard deviation ratios for all industries can be represented by an ordered vector with elements sampled from a beta distribution.

The steps for estimating each industry's standard deviation are as follows (for illustrative purposes, only the benchmark I-O accounts are discussed but the process is performed on the GDP-by-industry accounts as well):

1. For the benchmark I-O accounts, set candidate values for the two parameters of the beta distribution as a starting point. This distribution is evaluated as a candidate for characterizing the underlying distribution of point estimate–standard deviation ratios for all industries in the benchmark I-O accounts.
2. Sample sixty-one values from the distribution from step 1.
3. Rank order the sixty-one values from step 2 and assign one to each benchmark industry based on its ordinal ranking.
4. For each industry, use the assigned point estimate–standard deviation ratio and the known point estimate to determine the implied standard

deviation—that is, solve the following equation for industry *i*'s standard deviation.

$$\text{Error Metric}_i = \frac{\text{Standard Deviation}_i}{\text{Point Estimate}_i}$$

5. Repeat this process many times (on average, about 5,000 times), storing the implied standard deviations of the industry estimators from each repetition.
6. Compute the average of the sampled standard deviations for each industry using the results from step 5; use this average to develop a 95 percent confidence interval based on the *normal* distribution—that is,

$$N(\text{Point Estimate}_i, \text{Average Standard Deviation}).$$

7. Compare the upper and lower bounds of the confidence interval estimated in step 6 with the original 95 percent confidence interval estimated for the benchmark I-O accounts.
8. Repeat steps 1 through 7 with all candidate beta parameters. Find the beta parameters that minimize the sum of squared deviations between the 95 percent confidence intervals from the benchmark I-O accounts and those from step 6.
9. After estimating the beta parameters from step 8, follow steps 2 through 6 to estimate the standard deviation for each of the 61 industries in the benchmark I-O accounts.

This procedure approximates the estimator variance for each benchmark I-O and GDP-by-industry value-added estimate. The estimator variance estimates are used to determine the weights for the combined estimates. Estimators with smaller variances are given greater weight; that is to say, the following weights are used to estimate the combined level of value added for each industry:

$$b_{i,\text{I-O}} = \frac{\sigma^2_{i,\text{GDP by Industry}}}{\sigma^2_{i,\text{GDP by Industry}} + \sigma^2_{i,\text{I-O}}} \text{ and } b_{i,\text{GDP by Industry}} = \frac{\sigma^2_{i,\text{I-O}}}{\sigma^2_{i,\text{GDP by Industry}} + \sigma^2_{i,\text{I-O}}}$$

Appendix B

New Updating and Balancing Processes for the BEA's Annual I-O Tables

Since 1999, when the BEA reinstated its annual I-O program beginning with the release of accounts for 1996, the BEA has had among its many goals that of releasing annual I-O tables on a schedule synchronized with that for the

GDP-by-industry accounts. To achieve this goal implies regularly providing a time series of annual I-O tables with those for the most recent years being updated and revised through the standard advance, preliminary, and final iterations—a potentially very resource-intensive process.

The five broad tasks required to produce annual I-O tables were identified and discussed in the main body of this chapter (see section 6.4.4). In evaluating likely prospects for increased automation, the BEA focused on the last task, "balancing the use table," which has tended to be very labor intensive because of the BEA's extensive use of hand adjustments for the process. This appendix summarizes the results of the BEA's research in this area and describes the changes being incorporated into the current balancing procedures for the 1998–2002 annual I-O accounts.[23]

The appendix is divided into three sections. The first section describes the BEA's new balancing procedure. The second section describes the different tests that the BEA performed on this procedure before it was adopted. The third section provides summary remarks.

Expanded Automation of Balancing Procedures

The BEA has developed a new set of automated procedures for balancing its time series of integrated annual I-O tables for 1998 to 2002. Consistent with the research results, the new balancing procedures

- are based on a biproportional adjustment process;
- balance the I-O table in producers' and purchasers' prices simultaneously;
- incorporate more exogenous data; and
- process the tables at the most detailed level of data feasible.

The new procedures generally begin with an I-O use table that has been updated, following steps 1 through 4 described in the main body of this chapter. The I-O use table matrix is then balanced in both basic prices and purchasers' prices. (The purchasers' price equals the basic price plus commodity taxes, transportation costs, and margin costs.) This process allocates transportation costs and margin costs to industries and final uses as functions of how the commodities are moved by the economy's transportation system (rail, truck, water, air, pipeline, and gas pipeline) and through its distribution channels (wholesale trade and retail trade). In the use table, these costs are summed for each industry and shown as separate commodity purchases.

The new balancing procedures require fifteen matrices, each of which must be balanced internally while maintaining the different relationships

23. For further information on this research, see Planting and Guo (2004). The complete paper can also be obtained from the BEA's web site at http://www.bea.gov/bea/papers/Timeliness.pdf.

specified among matrices. The following matrices are prepared: a matrix with commodities valued in basic prices and one in purchasers' prices; one for commodity taxes; one for each of the six transportation modes (rail, truck, water, air, oil pipe, and gas pipe); one for wholesale trade margin; one for retail trade margin; and two matrices for taxes by each type of margin (see figure 6.B1). The transportation and wholesale trade matrices are of the same dimensions as those for producers' and purchasers' prices. The retail trade matrix is a single vector with one margin total for all consuming industries and final users. The matrix valued in basic prices is related to that valued in purchasers' prices through the taxes, transportation, and trade matrices. A cell in the purchasers' value matrix equals the corresponding cell in the basic value matrix plus the cells in the taxes, transportation, and trade matrices; conversely, a cell in the basic value matrix equals the corresponding cell in the purchasers' value matrix less those in the taxes, transportation, and trade matrices.

Control totals are identified for each matrix. The basic price, tax, transportation, and trade matrices are two-dimensional and have separate control totals for each row or commodity. The retail trade margin matrices are one-dimensional and have single control totals for the margin, sales tax, and other retail tax. The purchasers' price matrix is two-dimensional and is the sum of producers' price inputs plus transportation and trade margin costs; it has column control totals for each industry and final use category.

Detailed NIPA estimates, in purchasers' prices, are used as controls for the different types of final uses. These detailed data provide the basis for expanding estimates of personal consumption expenditures from 1 to 210 categories; gross private fixed investment from 1 to 33; structures, from 1 to 26; and government expenditures and investment from 6 to 136. Elements that remain constant or fixed in all matrices include exports, imports, changes in business inventories, and other negative cells.

Balancing the fifteen matrices is complex and requires several steps and iterations. Beginning first with the rows, adjustment factors are calculated, equaling the row control less the sum of the fixed cells in the row, divided by the sum of the new cells less the fixed cells. These adjustment factors are applied to the row cells that are not fixed in each matrix. The purchasers' price matrix is then calculated as the sum of the twelve other matrices. To balance the columns, adjustment factors are again calculated, this time equaling the column control less the sum of the fixed cells in the column, divided by the sum of the column cells less the fixed cells. These factors are then applied to the column cells that are not fixed in each matrix. The cells in the basic price matrix are then calculated as the difference between the purchasers' price and the sum of the twelve other matrices.

After a set number of iterations, and when the cells are close to being balanced in both basic and purchasers' values, then the taxes, transportation, and trade matrices are forced to also balance to their respective row

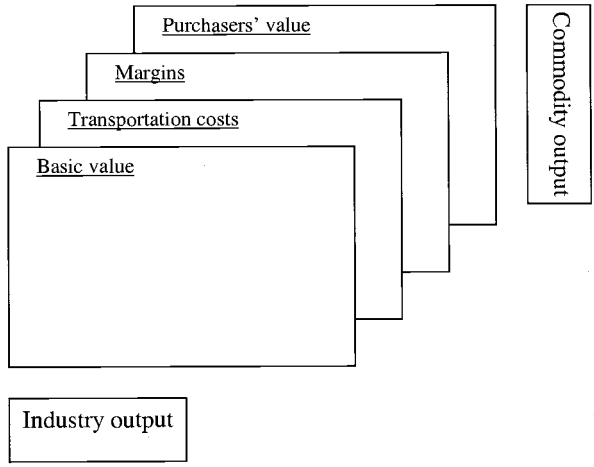


Fig. 6.B1 Relationship between basic value and purchasers' value matrices in the new balancing model

control totals. The balancing of the taxes, transportation, and trade matrices is delayed until the matrices valued in basic and purchasers' prices are approximately balanced in order to maintain the initial tax rates, transportation cost rates, and trade margin rates as long as possible.

Tests on the New Procedures

The BEA tested both the new balancing procedures and an alternative, more highly automated set of procedures, referred to as a "basic model," using an old work file with 1997 detailed data. Results were then compared to the published 1997 annual I-O use table. Unlike the new procedures, which balance multiple matrices, the basic model balances the table in producers' prices only. To evaluate the results from the two approaches, a set of tests were designed to answer the following questions:

- Does balancing in both producers' and purchasers' prices improve results? Most I-O tables are balanced in producers' prices (basic model). However, balancing in producers' prices ignores the detailed estimates of final use expenditures from the NIPAs, which are valued in purchasers' prices as well as the relationships between transportation and margin costs and the use of goods. It is hypothesized that valuing in purchasers' prices and using detailed data from the NIPAs improve the reliability of the balancing model.
- Does the addition of known estimates of value added for industries improve results? Value added makes up a significant portion of each industry's input structure. It is hypothesized that providing estimates

of value added for industries significantly reduces necessary adjustments and improves overall results. (Value added is determined endogenously as a residual for the basic model.)
- Does greater industry and commodity detail improve the results? The more aggregated the table, the more diverse the mix of products grouped together as a single commodity and the more diverse the market. Conversely, the more disaggregated the table, the more specialized commodities are to different markets. It is hypothesized that using more detail at the working level improves the initial distributions of commodities to users and, consequently, also improves the reliability of the balancing model.

To answer these questions, the BEA designed twelve tests that could be used to compare results from the new procedures with those from the basic model. Each version of a use table was balanced, using both the new adjustment process and the basic adjustment process. For the balancing, each was run through forty iterations. Each final use table was then collapsed to the summary level and compared to the published 1997 annual I-O use table.

The measure used for comparing results is the direct coefficient—that is, the amount of a commodity required by an industry to produce a dollar of output. The fewer the differences in direct coefficients between the balanced tables and the published 1997 annual table, the better the balancing model. Our comparisons were limited to the larger cells of the use table, that is, to direct coefficients with underlying intermediate values of $100 million or greater in producers' prices, and to those cells with absolute value difference (published less the balanced direct coefficient) of greater than 0.01 for direct coefficients.

Table 6B.1 provides the major test results. Overall, large coefficient differences decreased from 11.7 percent for the basic model, balanced at the publication level of data and using value added calculated as a residual, to 5.8 percent for the new model, balanced at the source data level and using independent, fixed value-added estimates. The major conclusions from the tests are as follows:

- Results from the new balancing procedures are better than those from the basic model.
- Working with more detail data improves results.
- The addition of known value-added estimates improves results.
- The new balancing procedures result in only 5.8 percent of the direct coefficients changing by more than 0.01 with an absolute average change of 0.029.

Conclusions

One of the BEA's goals has been to develop the capability for producing I-O tables that are more current but are not extremely resource intensive to produce. Research to this end has resulted in the BEA's development of

Table 6B.1 Large coefficient differences from the new balancing model compared with those from the basic balancing model

Model	Balancing level	Value added	Percent of cells with large coefficient differences	Mean absolute value of coefficient difference
Basic	Detailed publication level	Residual	11.7	0.027
		Fixed	9.8	0.025
	Source data level	Residual	8.3	0.030
		Fixed	6.5	0.028
New	Detailed publication level	Residual	7.3	0.032
		Fixed	9.6	0.027
	Source data level	Residual	7.3	0.033
		Fixed	5.8	0.029

Note: Large coefficient differences are defined as those greater than 0.01 from the same cell in the published 1997 input-output use table.

new automated procedures for balancing its use tables. From the test results examined, it is concluded that the best results are obtained when balancing in both purchasers' and basic prices. The test results also show that providing fixed estimates of value added and working at the detailed source data level both improve final results. However, although the new procedures produce use tables that are fairly comparable to the published table, the remaining differences are still important. Additional research is needed to evaluate these remaining coefficient differences and their causes.

Appendix C

Computing Chain-Type Price and Quantity Indexes in the GDP-by-Industry Accounts

The computation of the chain-type Fisher price and quantity indexes for gross output, intermediate inputs, and value added for an industry or an aggregate is summarized below. The value-added price index for an industry represents the price of its primary factors of production—that is, it represents the price of capital and labor used in the production of gross output. Similarly, the value-added quantity index for an industry represents the quantity of capital and labor used in the production of gross output.

Chain-Type Price Indexes

In the notation, $LP_{t-1,t}$ refers to the Laspeyres price relative for the years $t - 1$ and t; $PP_{t-1,t}$ refers to the Paasche price relative; $FP_{t-1,t}$ refers to the

Fisher price relative; and CP_t refers to the Fisher chain-type price index. The superscript GO refers to gross output, II refers to intermediate inputs, and VA refers to value added; p refers to detailed prices, and q refers to quantities.

Laspeyres price relatives for gross output, intermediate inputs, and value added, respectively, are

$$LP^{GO}_{t-1,t} = \frac{\sum p^{GO}_{t} q^{GO}_{t-1}}{\sum p^{GO}_{t-1} q^{GO}_{t-1}},$$

$$LP^{\Pi}_{t-1,t} = \frac{\sum p^{\Pi}_{t} q^{\Pi}_{t-1}}{\sum p^{\Pi}_{t-1} q^{\Pi}_{t-1}}, \text{ and}$$

$$LP^{VA}_{t-1,t} = \frac{\left(\sum p^{GO}_{t} q^{GO}_{t-1}\right) - \left(\sum p^{\Pi}_{t} q^{\Pi}_{t-1}\right)}{\left(\sum p^{GO}_{t-1} q^{GO}_{t-1}\right) - \left(\sum p^{\Pi}_{t-1} q^{\Pi}_{t-1}\right)}.$$

Paasche price relatives for gross output, intermediate inputs, and value added are

$$PP^{GO}_{t-1,t} = \frac{\sum p^{GO}_{t} q^{GO}_{t}}{\sum p^{GO}_{t-1} q^{GO}_{t}},$$

$$PP^{\Pi}_{t-1,t} = \frac{\sum p^{\Pi}_{t} q^{\Pi}_{t}}{\sum p^{\Pi}_{t-1} q^{\Pi}_{t}}, \text{ and}$$

$$PP^{VA}_{t-1,t} = \frac{\left(\sum p^{GO}_{t} q^{GO}_{t}\right) - \left(\sum p^{\Pi}_{t} q^{\Pi}_{t}\right)}{\left(\sum p^{GO}_{t-1} q^{GO}_{t}\right) - \left(\sum p^{\Pi}_{t-1} q^{\Pi}_{t}\right)}.$$

Fisher price relatives for gross output, intermediate inputs, and value added are

$$FP^{GO}_{t-1,t} = \sqrt{LP^{GO}_{t-1,t} \times PP^{GO}_{t-1,t}},$$
$$FP^{\Pi}_{t-1,t} = \sqrt{LP^{\Pi}_{t-1,t} \times PP^{\Pi}_{t-1,t}}, \text{ and}$$
$$FP^{VA}_{t-1,t} = \sqrt{LP^{VA}_{t-1,t} \times PP^{VA}_{t-1,t}},$$

Fisher chain-type price indexes for gross output, intermediate inputs, and value added for years after the reference year are

$$CP^{GO}_{t} = CP^{GO}_{t-1} \times FP^{GO}_{t-1,t},$$
$$CP^{\Pi}_{t} = CP^{\Pi}_{t-1} \times FP^{\Pi}_{t-1,t}, \text{ and}$$
$$CP^{VA}_{t} = CP^{VA}_{t-1} \times FP^{VA}_{t-1,t}.$$

In the reference year (2000 for this comprehensive revision),

$$CP_t^{GO} = CP_t^{\Pi} = CP_t^{VA} = 100.$$

Chain-Type Quantity Indexes

In the notation, $LQ_{t-1,t}$ refers to the Laspeyres quantity relative for the years $t-1$ and t; $PQ_{t-1,t}$ refers to the Paasche quantity relative; $FQ_{t-1,t}$ refers to the Fisher quantity relative; and CQ_t refers to the Fisher chain-type quantity index. The superscript GO refers to gross output, Π refers to intermediate inputs, and VA refers to value added; p refers to detailed prices, and q refers to quantities.

Laspeyres quantity relatives for gross output, intermediate inputs, and value added, respectively, are

$$LQ_{t-1,t}^{GO} = \frac{\sum p_{t-1}^{GO} q_t^{GO}}{\sum p_{t-1}^{GO} q_{t-1}^{GO}},$$

$$LQ_{t-1,t}^{\Pi} = \frac{\sum p_{t-1}^{\Pi} q_t^{\Pi}}{\sum p_{t-1}^{\Pi} q_{t-1}^{\Pi}}, \text{ and}$$

$$LQ_{t-1,t}^{VA} = \frac{\left(\sum p_{t-1}^{GO} q_t^{GO}\right) - \left(\sum p_{t-1}^{\Pi} q_t^{\Pi}\right)}{\left(\sum p_{t-1}^{GO} q_{t-1}^{GO}\right) - \left(\sum p_{t-1}^{\Pi} q_{t-1}^{\Pi}\right)}.$$

Paasche quantity relatives for gross output, intermediate inputs, and value added are

$$PQ_{t-1,t}^{GO} = \frac{\sum p_t^{GO} q_t^{GO}}{\sum p_t^{GO} q_{t-1}^{GO}},$$

$$PQ_{t-1,t}^{\Pi} = \frac{\sum p_t^{\Pi} q_t^{\Pi}}{\sum p_t^{\Pi} q_{t-1}^{\Pi}}, \text{ and}$$

$$PQ_{t-1,t}^{VA} = \frac{\left(\sum p_t^{GO} q_t^{GO}\right) - \left(\sum p_t^{\Pi} q_t^{\Pi}\right)}{\left(\sum p_t^{GO} q_{t-1}^{GO}\right) - \left(\sum p_t^{\Pi} q_{t-1}^{\Pi}\right)}.$$

Fisher quantity relatives for gross output, intermediate inputs, and value added are

$$FQ_{t-1,t}^{GO} = \sqrt{LQ_{t-1,t}^{GO} \times PQ_{t-1,t}^{GO}},$$

$$FQ_{t-1,t}^{\Pi} = \sqrt{LQ_{t-1,t}^{\Pi} \times PQ_{t-1,t}^{\Pi}}, \text{ and}$$

$$FQ_{t-1,t}^{VA} = \sqrt{LQ_{t-1,t}^{VA} \times PQ_{t-1,t}^{VA}},$$

Fisher chain-type quantity indexes for gross output, intermediate inputs, and value added for years after the reference year are

$$CQ_t^{GO} = CQ_{t-1}^{GO} \times FQ_{t-1,t}^{GO},$$

$$CQ_t^{\Pi} = CQ_{t-1}^{\Pi} \times FQ_{t-1,t}^{\Pi}, \text{ and}$$

$$CQ_t^{VA} = CQ_{t-1}^{VA} \times FQ_{t-1,t}^{VA}.$$

In the reference year (2000 for this comprehensive revision),

$$CQ_t^{GO} = CQ_t^{\Pi} = CQ_t^{VA} = 100.$$

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