CBO MEMORANDUM

CHANGING THE TREATMENT
OF SOFTWARE EXPENDITURES
IN THE NATIONAL ACCOUNTS

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Statistics from the national economic accounts play an important role in economic forecasting, both for federal agencies and the private sector. One issue of recent concern has been whether the way those accounts treat businesses' spending on software makes current statistics misleading. This memorandum describes how an alternative treatment of software spending would affect the accounts and provides rough estimates of those effects. The analysis was undertaken as background research in support of the Congressional Budget Office's (CBO's) work on economic forecasting.

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CONTENTS

TABLES

FIGURE

SUMMARY

Businesses in the United States spend large amounts of money on information technology each year. According to official statistics, their spending on computers and peripheral equipment (known as hardware) now accounts for 10 percent of the nation's nonresidential investment and 1 percent of its gross domestic product (GDP). Businesses' spending on software, by contrast, does not contribute to measured investment or GDP because it is excluded from the measure of investment used in the national income and product accounts (NIPAs). The reason is not one of definition—software spending generally fits the definition of an investment—but rather a lack of data and research on the measuring tools that would be needed to properly incorporate software spending into the national accounts.

The resulting understatement of investment affects various important statistics, such as GDP and estimates of the nation's capital stock. The size of the problem is not clear, but some observers have suggested that it could lead to a substantial misstatement of current growth in U.S. output and productivity.

Knowing the order of magnitude of that omission would be useful in interpreting current statistics, and some limited information is available. The Congressional Budget Office (CBO) has used that information to approximate what would happen to various NIPA statistics if software purchases were treated as a form of investment, instead of their current treatment as an intermediate good (something that, like energy or other inputs, is used up in the production of goods and services). One factor makes gauging the magnitude of such a change especially complicated: companies outside the software industry produce some software for their own use. Those production costs should be included in software investment, but the amount of such activity is not measured. Because of that difficulty, CBO's analysis focuses primarily on estimates of software that businesses buy from the software industry. As a result, the estimates provide a lower bound for the effects of changing the treatment of software.

Not counting software produced in-house, treating software as an investment in the relevant parts of the national accounts would increase the estimate of investment for 1995 (the latest year for which data are available) by about $47 billion, or 4.5 percent. That change would result in a proportionally smaller increase in measured GDP, about 0.7 percent.

The effect on the year-to-year growth rate of nominal GDP would be negligible: growth from 1994 to 1995 would remain at the official estimate of 4.6 percent. The effect on the real (inflation-adjusted) growth rate could be substantially larger. However, it would depend on the rate at which quality-adjusted software prices are declining—something about which there is little current information. If prices are declining at a rate of 3 percent a year, the real growth rate including software investment would be almost 0.1 percentage point higher in 1995 than the official estimate of 2.0 percent. If instead the rate of price decline is 15 percent, the effect of adding in software would be to increase the growth rate by around 0.2 percentage points.

A change in the treatment of software would increase the measured capital stock by an estimated 0.3 percent to 1.0 percent, depending on assumptions about rates of depreciation and price change. The increase in the stock of producers' durable equipment (that part of the capital stock to which software would be added) would be proportionally larger—between 1.5 percent and 5.3 percent—again depending on the assumed rates of price decrease and depreciation. The effects on measured corporate profits and on the statistical discrepancy (the difference between the income and product sides of the NIPAs) are uncertain.

The changes estimated in this analysis are quite small relative to total GDP, which suggests that incorporating software into the national accounts would have little effect on the measured size of the U.S. economy. It could be more important, however, for other statistics that affect understanding of the current state of the economy and its likely future—for example, the real growth rate of the economy and measures of investment. Determining whether that is the case requires having better information on the rate at which software prices are changing.

The agency responsible for producing the NIPA statistics, the Bureau of Economic Analysis (BEA), plans to change the current treatment of software: its strategic plan for maintaining and improving the national accounts includes expanding the definition of the investment component of GDP to include spending on computer software. Some of the research and data collection necessary for that expansion have begun, both at BEA and the Bureau of Labor Statistics. But more remains to be done before the change can be made. One difficulty is that current financial and tax accounting rules do not provide for clear treatment of software spending, which makes collecting data on that spending from businesses more complicated.

INTRODUCTION

U.S. businesses have spent hundreds of billions of dollars on information technology over the past decade. Spending by businesses on computers and peripheral equipment (hardware) now accounts for 10 percent of the country's nonresidential investment and 1 percent of its gross domestic product (GDP), as officially measured. Businesses' spending on software, by contrast, makes no contribution to measured investment or GDP because it is excluded from those measures in U.S. economic statistics. The reason is not some general agreement that it ought to be excluded; on the contrary, most software spending fits the definition of an "investment good" in that it is used in a production process for more than one year. Rather, a scarcity of data and a lack of research on the measuring tools that would be necessary make it difficult to properly incorporate such spending into the national economic accounts.

Accurately knowing the amount of investment that occurs each year in the United States is important both for understanding current economic conditions and for forecasting future economic growth. The omission of software means that current statistics understate investment rates, perhaps substantially. That understatement of investment in turn affects other statistics, such as GDP and the nation's estimated capital stock. Although the size of the problem is not yet clear, some observers have suggested that the omission of software spending may have a significant effect on measures of current growth in output and productivity. This Congressional Budget Office (CBO) analysis uses the available data to approximate how changing the official treatment of software purchases—specifically, treating them as an investment—would affect various statistics from the national accounts.

THE CURRENT TREATMENT OF SOFTWARE IN THE NATIONAL ACCOUNTS AND AN ALTERNATIVE

The primary investment data for the United States come from the national income and product accounts (NIPAs), part of a set of accounts compiled by the government to provide a comprehensive picture of the nation's economy. Probably the most familiar statistic from those accounts is GDP, which totaled around $8 trillion in 1997. The NIPAs include two parallel sets of measures, the product account and income account. The product account records the value and composition of U.S. economic output; its total is GDP. The income account shows how the incomes generated in producing that output are distributed—what part goes to employee compensation, to corporate profits, and so forth.

The components of total output and income are used in a variety of other measures that focus on specific parts of the economy. Of particular relevance to the definition of investment, measures of investment from the product account are used to produce estimates of the nation's capital stock—the total value of structures and equipment now in place. The capital stock is important both as a measure of the country's current wealth and as a measure of productive capacity for forecasts of future output. Estimates of the capital stock in turn feed into a variety of other economic statistics, such as total factor productivity and net measures of output.

The treatment of software enters into the estimation of those three parts of the accounts (the product account, income account, and capital stock) in different ways, so it is useful to consider each one separately.

Treatment in the Product Account

Gross domestic product is estimated by adding together the value of all final goods and services produced in the United States. (Goods and services are considered final if they are either consumed or added to the stock of assets.) Under current methodology, business spending on software is generally treated as an intermediate input in those accounts—that is, as an input that is used up in production, just like the electricity or cleaning supplies that businesses purchase. The product account does not add in the value of intermediate goods because doing so would involve double-counting: part of the cost of final goods is accounted for by the purchase of the intermediate goods used to make them, so adding intermediate goods to a measure of total output would mean counting them twice. Because intermediate goods do not enter directly into the total, their value does not have to be measured to produce the product account.

Entries in the product account are grouped by the sector that consumes the goods: personal consumption expenditures (goods and services consumed by U.S. households), net exports of goods and services (consumption by nonresidents), and government consumption expenditures and gross investment.[1] The account also includes a category, gross private domestic investment, for goods that are added to the stock of private fixed assets. That category is defined as investment in residential and nonresidential structures, changes in business inventories, and producers' purchases of durable equipment. Unlike software, producers' purchases of durable equipment are considered final rather than intermediate goods because even though the equipment helps in the manufacture of other goods, it is not used up in current production. Instead, it remains useful for more than one year. The gradual using up of those final, or investment, goods is captured in net measures of output through a deduction for depreciation—or "consumption of fixed capital," as the national accounts call it. Depreciation is not, however, deducted from gross measures of

1. There is no single NIPA table titled "Product Account" in publications of the Bureau of Economic Analysis. The description here generally corresponds to the information presented in Table 1.1, titled "Gross Domestic Product," in current issues of the *Survey of Current Business.*

output, so such measures as GDP include the full value of production of investment goods.

The Current Treatment of Software. The way in which software fits into the product account is most easily illustrated by showing how a set of transactions involving software would be treated in putting together an estimate of GDP. As a starting point, suppose that the nation produces a total of $1,000 worth of software this year. How much of that $1,000 is explicitly counted in measuring GDP depends on how it is distributed among different types of buyers. Suppose that consumers buy $50 of software, $50 is exported, governments buy $200, and the remaining $700 is purchased by U.S. businesses. All purchases of goods by consumers, governments, or nonresidents are treated as final goods; hence, $300 would be counted in GDP.

What of the $700 in business purchases? They are treated as spending on an intermediate good and thus are not explicitly included in GDP. However, software bought by businesses is used to produce other goods and services, so it contributes indirectly through the value of other, final goods. To capture that indirect contribution, the example should include an amount to represent software's contribution to the value of final goods and services.

What is that value? If software were truly an intermediate good—and so, by definition, would not be useful in production after one year—its contribution would be expected to equal its cost ($700 in this example). Indeed, that is the rationale for the way the NIPAs treat intermediate goods. But because software functions more like an investment good and is used to produce goods or services over several years, a business would not receive the full return on its investment in the year of purchase. As a result, the $700 in software that businesses bought in the current year would be used to produce less than $700 in final output this year. Software purchased in earlier years would also contribute to the value of this year's total output, and conceivably, the total contribution from current and past software investment might be greater than $700. If business investment in software was growing rapidly, however, software's contribution to output would probably be somewhat less than $700. With that in mind, this example assumes that software is used to produce $500 worth of services purchased by U.S. consumers, which would be categorized as personal consumption expenditures.[2]

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2. It would be difficult to produce a service using software alone. The amount that is counted here as the contribution of software represents the difference between the total value of the output and the cost of other inputs. Some of the final goods produced using software would undoubtedly be purchased by governments, be investment goods, or be exported. To simplify the discussion of this example, however, all such output is assumed to be purchased by consumers.

Putting those parts together, the transactions described above would account for $800 of GDP under current NIPA rules: $300 in final purchases of software and $500 in final services produced by software. Of that $800, $550 would fall under personal consumption expenditures ($50 in consumer purchases of software plus the $500 in consumer purchases of services produced using software). The other $250 would be split between $50 in net exports of software and $200 in government purchases of software (see Table 1).

Because the $700 purchased by U.S. businesses is treated as spending on an intermediate good, it does not appear as a separate entry. In the same way, if a business uses $700 worth of staff time to develop software for its own use instead of purchasing some from a software producer, that expenditure is also implicitly treated as an intermediate good, and no explicit addition to GDP is made for the $700 worth of staff time.

One portion of business spending on software is counted as an investment: spending on software that is embedded in hardware, such as an operating system that comes already installed on a new computer. In that case, the price of the computer includes payment for the software as well as the hardware. Since the full price is included in producers' purchases of durable equipment, such software is implicitly treated as an investment good.

<u>Treating Software as an Investment</u>. An alternative to the current methodology would be to treat all spending on software by businesses or governments as investment and, hence, explicitly count it as part of GDP (a treatment analogous to that of durable equipment). That change would involve three important adjustments to the product side of the NIPAs.

- Measured gross private domestic investment would increase by the amount of annual business spending on software. For example, in Table 1, gross private domestic investment rises by $700 to account for business purchases of software.

- Measured government consumption expenditures would increase by the amount of depreciation on accumulated government purchases of software, to represent the value of services provided by government-owned software. In the example shown in Table 1, that value is assumed to be $100.

- Measured GDP would increase by both amounts (business software spending and the rise in measured government consumption expenditures).

TABLE 1. AN ILLUSTRATION OF ALTERNATIVE TREATMENTS OF SOFTWARE IN THE PRODUCT ACCOUNT (In dollars)

	$1,000 in Annual Software Production in the United States[a]	
Components of the Product Account	Under Current Methodology (Software treated as an intermediate good)	Under Alternative Methodology (Software treated as an investment good)
Personal Consumption Expenditures[b]	550	550
Net Exports of Goods and Services	50	50
Government Expenditures[c]	200	300
Gross Private Domestic Investment	0	700
Gross Domestic Product	800	1,600

SOURCE: Congressional Budget Office.

a. Assuming that $50 of software is bought by U.S. consumers, $50 is exported, $200 is bought by governments in the United States, and $700 is bought by U.S. businesses.

b. Includes consumers' purchases of software and of services produced using software.

c. Comprises government consumption expenditures and gross investment.

Understanding the effect on measured government expenditures requires some discussion of the government sector in the NIPAs.[3] As noted earlier, the product account records the value of output, and in general the value of a good is measured simply by its purchase price. Measuring the value of government output presents difficulties, however, because most government production (such as law enforcement services) is not directly purchased by consumers. As an alternative, the product account uses the value of inputs as a proxy for the value of output, which requires measuring the value of all inputs. Goods and services purchased by the government sector (including the services of government employees) are simply valued at cost. Fixed assets owned by governments (such as police stations and patrol cars) also provide services that contribute to output, but no market transaction

3. For a more detailed discussion, see "Preview of the Comprehensive Revision of the National Income and Product Accounts: Recognition of Government Investment and Incorporation of a New Methodology for Calculating Depreciation," *Survey of Current Business* (September 1995), pp. 33-41. The NIPAs include a variety of tables that present information on the size and composition of the government sector. This discussion corresponds most closely to the sort of information provided in Table 3.7, "Government Consumption Expenditures and Gross Investment by Type," in current issues of the *Survey of Current Business.*

provides a value for those services. For lack of a better alternative, the account uses depreciation of governments' fixed assets—termed consumption of general government fixed capital—to measure the value of the services those assets provide.

In the case of software, that treatment is important because any change in what the accounts consider a fixed asset will affect the measure of services from fixed assets. If software is treated as an investment good, government purchases of software in a given year are shifted from government consumption expenditures to government investment, which by itself is simply a relabelling that does nothing to alter GDP (see Table 2). However, the accumulated stock of government-purchased software is then counted as a fixed asset, so its depreciation is added to government consumption and, hence, to GDP.[4]

In the current example, the $100 in depreciation included in consumption of fixed capital accounts for the difference between total transactions attributed to software ($1,500) and the total contribution of software to GDP if software is treated as an investment good ($1,600).

Treatment in the Income Account

The income account adds up payments to the factors used to produce goods—labor and capital—plus some other, nonfactor charges. The account's components are compensation of employees, proprietors' income (the income of noncorporate businesses), rental income of persons, corporate profits, net interest, and nonfactor charges (including consumption of fixed capital). The sum of the income account is gross domestic income (GDI). In theory GDI should equal GDP, its equivalent on the product side of the accounts, but in practice the use of different sources of data for the two sides means that they are not identical. The difference between them is called the statistical discrepancy (defined as GDP minus GDI). GDI has grown faster than GDP in recent years and now exceeds it, so the statistical discrepancy is negative.[5]

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4. The depreciation amount depends on software purchases in earlier years as well as the current year, so it cannot be calculated directly from current spending on software.

5. The NIPAs include a variety of tables giving information on income, but none corresponds exactly to a summary table for GDI. In current issues of the *Survey of Current Business*, Table 1.14, "National Income by Type of Income," gives measures that would correspond to the primary components of GDI, except that they are shown in terms of national rather than domestic income. The difference comes in the treatment of factor income received from and paid to the rest of the world. Table 1.9, "Relation of GDP, Gross National Product, Net National Product, National Income, and Personal Income," gives the relationship between GDP and national income, including the size of the statistical discrepancy. The presentation here deviates from that in the NIPA tables to simplify the comparison of how software is treated on the income and product sides of the accounts.

TABLE 2. AN ILLUSTRATION OF ALTERNATIVE TREATMENTS OF SOFTWARE IN THE GOVERNMENT SECTOR OF THE PRODUCT ACCOUNT (In dollars)

Components of Government Expenditures	$200 in Annual Software Purchases by Governments in the United States: Under Current Methodology (Software treated as an intermediate good)	Under Alternative Methodology (Software treated as an investment good)
Government Consumption Expenditures		
Consumption of general government fixed capital	0	100
Other consumption expenditures	200	0
Government Gross Investment	0	200
Government Expenditures	200	300

SOURCE: Congressional Budget Office.

The Current Treatment of Software. Whether software is treated as an intermediate good or an investment good figures into the income side of the accounts most prominently in measuring corporate profits and consumption of fixed capital. Purchases of intermediate products (including software) are treated as a current expense and thus are subtracted from income in calculating profits. Purchases of investment goods, by contrast, reduce profits through a depreciation charge rather than an immediate deduction. To calculate GDI, depreciation is added back in under the title consumption of fixed capital. Thus, consistent with the product side, gross measures of income include the full value of businesses' payments for investment goods.

The earlier example can illustrate that principle with a bit of added detail. From the aforementioned $1,000 worth of software, assume that $900 in income goes to compensate the employee time used in producing the software. Further, suppose for simplicity that all business purchases of software are made by corporations, so corporations receive the revenues from selling any goods and services produced using software. In that case, under current NIPA methodology, software transactions would result in $900 of employee compensation and -$100 in corporate profits (see Table 3). The -$100 reflects the $100 in profits remaining to software producers after

TABLE 3. AN ILLUSTRATION OF ALTERNATIVE TREATMENTS OF SOFTWARE IN THE INCOME ACCOUNT (In dollars)

	$1,000 in Annual Software Sales in the United States[a]	
Components of the Income Account	Under Current Methodology (Software treated as an intermediate good)	Under Alternative Methodology (Software treated as an investment good)
Compensation of Employees	900	900
Proprietors' Income	0	0
Rental Income of Persons	0	0
Corporate Profits	-100	150
Net Interest	0	0
Nonfactor Charges		
Consumption of fixed capital	0	550
Other	0	0
Gross Domestic Income	800	1600

SOURCE: Congressional Budget Office.

a. Assuming that $50 of software is sold to U.S. consumers, $50 is exported, $200 is sold to governments in the United States, and $700 is sold to U.S. businesses.

paying their employees and a -$200 net effect on the profits of corporations that buy software. That -$200 is the difference between the previously discussed $500 in revenues from sales of services produced using both new and old software and the $700 expense of businesses' current software purchases. The net effect is an $800 contribution to GDI, which equals the contribution of software to GDP, as shown in Table 1.

Treating Software as an Investment. If spending on software by businesses or governments was considered an investment, the income side of the NIPAs would change in three important ways. First, corporate profits as measured in the NIPAs would increase by the difference between corporations' software spending and the depreciation of their accumulated investment in software. That is, current spending would no longer be treated as an expense, thereby reducing expenses and raising profits. But that rise would be at least partially offset by the deduction of software depreciation. While software purchases are growing, however, current purchases will exceed depreciation of accumulated purchases, and measured corporate profits will increase.

In the example in Table 3, depreciation of accumulated corporate investment in software is assumed to equal $450—somewhat less than that software's contribution to output—to allow for some return on the funds invested in it. NIPA corporate profits increase by $250, the difference between the $700 in current software spending that is now treated as an expense and the $450 in depreciation that would be deducted instead if purchases were treated as an investment. Unincorporated businesses also undoubtedly purchase software, so part of the adjustment to a change in methodology would show up as an increase in proprietors' income, but this example omits that issue for the sake of simplicity.

Second, depreciation of accumulated software investment by both businesses and governments would be added to consumption of fixed capital. In Table 3, consumption of fixed capital increases by $550, reflecting the assumed $450 in depreciation of corporate-owned software plus the $100 depreciation of government-owned software assumed in the discussion of the product account.

Third, GDI (like GDP) would increase by the amount of business software spending plus depreciation of the stock of government-owned software. In Table 3, that amounts to $800: $700 in corporate software spending plus $100 in depreciation of government-owned software. Note that, because corporate profits and depreciation are both components of gross domestic income, total GDI is not affected by the amount of depreciation of business-owned software. That depreciation is subtracted from revenues in calculating corporate profits but is added to consumption of fixed capital.

Thus, in theory, the net effect of treating software spending as an investment would be to raise GDI by the same amount as GDP. In practice, however, part of that change might show up as a change in the statistical discrepancy, because software purchases may have some role in the fact that GDI exceeds GDP in current NIPA estimates.

Software's Role in the Statistical Discrepancy

Software purchases contribute to the statistical discrepancy to the extent that their treatment on corporate tax returns differs from current NIPA accounting methods. The Bureau of Economic Analysis (BEA), which constructs the NIPAs, uses data from tax returns to estimate corporate profits for the income account. But because tax accounting standards differ in some ways from NIPA treatment, BEA makes various adjustments to the profit figures to conform to NIPA definitions. No explicit adjustment is made for software purchases, however. Such an adjustment would not be necessary if all corporations treated software purchases as an expense in figuring their taxes, because that would be consistent with NIPA methodology. But some, perhaps most, software purchases are not treated as an expense on corporate tax returns, since the tax code generally calls for capitalizing the purchase of long-lived software and then depreciating that cost over three years.

That difference in treatment affects the statistical discrepancy because the data on revenues and expenses used to compute corporate profits come from tax returns, but depreciation is based on accumulated investment as measured on the product side of the accounts—a measure that is consistent with current NIPA methods in that it does not include any depreciation of software.[6] Thus, if corporations capitalize software purchases rather than treating them as an expense on their tax returns, reported expenses are lower than what they should be under NIPA methodology. The result is that NIPA corporate profits are overstated by the amount of spending on software that is capitalized on corporate tax returns.

Because gross domestic income includes corporate profits as one of its components, it is overstated by the same amount as profits. A recent BEA publication points to such overstatement as one possible reason that GDI has been growing faster than GDP since the early 1990s.[7] If that is indeed a reason, then changing the treatment of software would raise GDP by more than GDI and thus narrow the statistical discrepancy.

Treatment in the Capital Stock

The NIPA measure known as the current-cost net stock of fixed private capital measures the value of equipment and structures owned by U.S. businesses and the value of residential structures.[8] To estimate the capital stock, BEA uses the "perpetual inventory" method: the current stock equals the sum of current and past investments, which are expressed in current-value terms using price indexes for the various types of investment and reduced by the amount of depreciation. For example, an investment good purchased for $1,000 a year ago would cost $1,100 today if the price of such goods had risen by 10 percent in the interim. With a

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6. An adjustment to tax-return-based profits is made through the addition of an amount termed "capital consumption adjustment" that is equal to the difference between tax-return-based calculations and economic depreciation. Adding that difference is equivalent to canceling the deduction of tax-return-based depreciation in calculating corporate profits and deducting economic depreciation instead.

7. Robert Parker and Eugene Seskin, "Annual Revision of the National Income and Product Accounts," *Survey of Current Business* (August 1997), p. 19.

8. For current estimates of the capital stock and details of the estimating methodology, see Arnold Katz and Shelby Herman, "Improved Estimates of Fixed Reproducible Tangible Wealth, 1929-1995," *Survey of Current Business* (May 1997), pp. 69-92.

depreciation rate of 20 percent over its first year in service, that investment would contribute $880 to the current capital stock.

As an intermediate good, software is excluded from the measured capital stock under current treatment. If software were reclassified as an investment good, the measured private capital stock would increase by the value of the stock of business software capital, based on accumulated software spending adjusted for depreciation and price changes.

THE ESTIMATED EFFECTS OF CHANGING THE TREATMENT OF SOFTWARE

Changing the national accounts to treat software as an investment good would require information that is not currently available. That information includes accurate measures of software spending by businesses, price indexes for software, and depreciation rates. However, by piecing together the limited information that is available, CBO has roughly estimated the effects of changing the treatment of a portion of software spending: purchases from software producers.

These estimates do not include software investments that businesses make by using their own resources to produce software for internal use. For example, a company might have one of its employees write computer code to carry out some task, rather than buying a software package or hiring a consulting firm to write the code. If the code produced is useful for more than one year, the cost of the employee's time should be counted as a form of software investment. No direct information is available on the amount of such activity, however. For that reason, the analysis described in this section focuses primarily on software purchases, which are more readily measured. However, the final subsection considers possible ways to measure that additional, "in-house," component.

The numbers given here illustrate the likely magnitude of the effects of a change in methodology. In coming up with a rough number, CBO attempted to err on the side of underestimating the effects, so that the estimates could be thought of as conservative. Where great uncertainty exists about the relevant magnitudes, the analysis considered a range of possibilities. (See the appendix for more details of how CBO produced the estimates.) The extent to which software is already treated as an investment in corporate profits in the income account is unclear, so the analysis did not estimate the effects on that account.

Effects on the Product Account

By CBO's estimate, business purchases of software totaled approximately $46.9 billion in 1995, the most recent year for which data are available. (That figure is based on the sales receipts of software firms adjusted for nonbusiness purchases.) Adding in that amount would boost estimated investment in producers' durable equipment in 1995 by 9.0 percent and the larger measure, gross private domestic investment for 1995, by 4.5 percent (see Table 4).

In addition, software spending would raise GDP by increasing the estimated value of services from government-owned fixed assets, a part of government expenditures. That increase would equal the estimated depreciation of the stock of government-owned software and would be included in the category consumption of general government fixed capital. Because that estimate is sensitive to assumptions about depreciation and rates of price decline (deflation), CBO used a variety of assumptions about those factors in its analysis. The figure in Table 4, $4.1 billion, is based on the combination of assumptions that produces the smallest estimate among the possibilities considered: a 15 percent annual decline in software prices (after adjusting for quality differences) and the NIPA depreciation schedule for personal computers (PCs).[9] That $4.1 billion represents only a 0.3 percent increase in measured government expenditures. At the other extreme of the possibilities considered, depreciation based on an assumed average service life of three years combined with a 3 percent annual decline in software prices yields an estimate of $11.4 billion, or a 0.8 percent rise in government expenditures.

Government purchases of software cost an estimated $13.6 billion in 1995. That amount would be added to government gross investment and subtracted from government consumption expenditures to reflect the reclassification of software as an investment good. The reclassification would not directly affect GDP, but it would increase measures of investment that include investment by governments.

Factoring in both business software purchases and the smallest estimate of the increase in government consumption would raise GDP by about 0.7 percent. Using the largest estimate of the increase in government consumption would raise GDP only slightly more, by 0.8 percent.

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9. Researchers' estimates of rates of price decline for software have ranged from 3 percent to 15 percent, so the analysis was carried out using those two extremes. The PC depreciation schedule assumes that an investment has lost almost 50 percent of its value after four years and virtually all of its value after 10 years. The ranges of deflation and depreciation assumptions are discussed in more detail in the appendix.

TABLE 4. ESTIMATED EFFECTS IN 1995 OF TREATING SOFTWARE AS AN INVESTMENT GOOD IN THE PRODUCT ACCOUNT (In billions of dollars)

	1995 NIPA Estimate	1995 NIPA Estimate Including Software	Dollar Difference	Percentage Difference
Major Components of the Product Account				
Personal Consumption Expenditures	4,957.7	4,957.7	0	0
Net Exports of Goods and Services	-86.0	-86.0	0	0
Government Expenditures	1,355.5	1,359.6	4.1	0.3
Gross Private Domestic Investment	1,038.2	1,085.1	46.9	4.5
Gross Domestic Product	7,265.4	7,316.4	51.0	0.7
More Detailed Components of the Product Account				
Producers' Durable Equipment	522.4	569.3	46.9	9.0
Consumption of General Government Fixed Capital	122.4	126.5	4.1	3.4
Other Government Consumption Expenditures	1,019.7	1006.1	-13.6	-1.3
Government Gross Investment	213.4	227.0	13.6	6.4

SOURCE: Congressional Budget Office.

NOTE: These estimates are based on the depreciation schedule for personal computers used in the national income and product accounts (NIPAs); they assume that quality-adjusted software prices have fallen 15 percent per year. For more details about how the estimates were constructed, see the appendix.

In terms of GDP growth, the change in methodology would have a negligible effect on the measured growth of nominal GDP between 1994 and 1995, but a more substantial effect on the real growth rate. Treating software as an investment good would lead to a measured nominal growth rate about 0.05 percentage points higher than the 4.6 percent rate under current methodology. The change in the real growth rate would be larger, but its size is sensitive to the assumed deflation rate for software: the growth rate for real GDP between 1994 and 1995 would be about 0.07 percentage points higher assuming 3 percent deflation, or about 0.17 percentage points higher assuming 15 percent deflation. Compared with a measured real growth rate of 2.0 percent in 1995, the effect of the change in methodology would be substantial if software prices were in fact falling rapidly.[10]

Effects on the Measured Capital Stock

The effect on the capital stock also depends on assumptions about deflation rates and depreciation schedules. Using the same sets of assumptions as for the product account produces a range of estimated increases in the private capital stock of 0.3 percent to 1.0 percent (see Table 5). Those estimates are particularly sensitive to the choice of depreciation schedule, with faster rates of depreciation leading to smaller estimated stocks. Price changes are also important. The faster the rate of price decrease, the less valuable software purchased several years ago is in terms of what similar software would sell for today, so the smaller the value of the current software stock. The stock of producers' durable equipment (the component of the capital stock to which software would be added) would see proportionally larger increases, ranging from 1.5 percent to 5.3 percent.

Adding in business spending on software would have a much smaller effect on the private capital stock than on gross private domestic investment (an increase of no more than 1.0 percent in 1995 versus 4.5 percent). That occurs both because software purchases have been growing relative to total investment expenditures and because of the assumed deflation rates and depreciation schedules. Most of the other assets included in the private capital stock have seen their prices rise over time, making a $1 investment in them in 1994 worth more than $1 when expressed in 1995 dollars. By contrast, prices for software have moved in the opposite direction. In addition, even the slowest depreciation rates used in this analysis are much faster than those used for structures, whose value accounts for 80 percent of the total capital stock. Under the personal-computer depreciation schedule, after seven years almost 90 percent of the value of a software purchase is assumed to have depreciated away (in the absence of price changes). Under the 10-year-service-life schedule, the equivalent figure is 74 percent. By contrast, an investment in one- to four-unit residential housing structures has lost only 8 percent of its value after seven years. (That category accounts for about one-third of the total private capital stock.)

By way of comparison, the estimated stock of hardware (computers and peripheral equipment) in 1995 was roughly on a par with the stock of software

10. Although the precise estimate depends on which depreciation schedule is used to measure the value of services from government-owned software, the range of estimates produced by alternative assumptions is narrow. The adjusted nominal growth rate varies from 4.63 percent to 4.64 percent. The adjusted real growth rate ranges from 2.14 percent to 2.16 percent with 15 percent deflation in software prices, but is always 2.05 percent with 3 percent deflation.

TABLE 5. ESTIMATED EFFECTS IN 1995 OF ADDING SOFTWARE TO THE CAPITAL STOCK

Depreciation Schedule	Estimated Software Capital Stock (Billions of dollars)	Percentage Increase in Private Capital Stock	Percentage Increase in Producers' Durable Equipment Stock
Software Prices Decline by 3 Percent a Year			
Three-Year Service Life	54.9	0.4	1.8
Ten-Year Service Life	149.3	1.0	4.8
Personal Computer Schedule	163.6	1.0	5.3
Software Prices Decline by 15 Percent a Year			
Three-Year Service Life	47.6	0.3	1.5
Ten-Year Service Life	107.3	0.7	3.4
Personal Computer Schedule	123.0	0.8	4.0

SOURCE: Congressional Budget Office.

NOTE: For more information about the depreciation schedules and assumed rates of price decline, see the appendix.

—$132.3 billion compared with $47.6 billion to $163.6 billion, depending on assumptions. Over the past several years, hardware investment has been 24 to 40 percent higher than the software investment estimated in this analysis. The fall in hardware prices, as measured by the NIPA deflator for that category, averaged about 14 percent a year over the 1991-1995 period. And although the depreciation schedule for personal computers is used for part of the hardware category, the other components (mainframes and various peripherals) have faster depreciation schedules. Together, those factors make the stock of hardware only 8 percent larger than the stock of software when the latter is estimated using a 15 percent deflation rate and the PC depreciation schedule. (Using the three-year-service-life depreciation schedule reduces the estimated software stock considerably, making it about 60 percent smaller than the hardware stock.)

In-House Software Production

CBO's estimates of investment in software and the stock of software capital are based only on purchases from firms in the software industry. Some businesses and government agencies also develop software using their own resources, but that form of investment is much more difficult to measure, and no entity systematically collects data on the value of resources devoted to producing software in-house.

Researchers have provided some estimates of in-house software production, but those estimates are generally based on indirect measures that contain a good deal of uncertainty. A 1979 study of software spending estimated that companies spent almost $9 billion in 1972 on writing and maintaining software in-house, while the software industry's revenues were estimated to be only $1 billion.[11] A more recent estimate implies that spending on in-house software development is roughly on the order of purchases from software producers.[12] The difference between earlier and more recent estimates suggests that in-house development of software has become relatively less important over time. Provisional estimates by BEA for 1987 and 1992 also indicate that in-house software investment has not grown as fast as software purchases.[13]

BEA's estimates represent an initial attempt to quantify the extent of in-house software expenditures for 1992. The bureau based its figures on the estimated number of people employed in computer-related occupations (as "computer programmers" or "computer systems analysts and scientists") outside the industries labeled "computer programming services" and "prepackaged software." BEA used survey data on the earnings of people in those occupations and adjusted the data upward to reflect the likely cost of employee benefits. It then adjusted that total compensation figure upward to reflect the value of resources other than employee time used to produce in-house software. That second adjustment was based on the ratio of total operating expenses to payroll in the computer programming and prepackaged-software industries; thus, it implicitly assumes that other inputs account for a similar fraction of costs in in-house software production as in software-producing industries.

BEA's figure for 1992 based on that method was $67.9 billion of private in-house software investment, compared with its estimate of $33.9 billion in business purchases from software producers in 1992. Carrying out similar calculations using 1995 data produces an estimate of $71.5 billion for private in-house investment and

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11. Montgomery Phister, *Data Processing Technology and Economics*, 2nd ed. (Santa Monica, Calif.: Santa Monica Publishing Company and Digital Press, 1979).

12. Organization for Economic Cooperation and Development, *Information Technology Outlook 1994* (Paris: OECD, 1994).

13. Robert Parker, "Estimation of Investment in Computer Software" (paper presented at the OECD-UNECE-EUROSTAT Meeting of National Accounts Experts, June 1997).

$16.7 billion for government in-house investment for that year.[14] Adding those figures to the estimates in Table 4 (which are based on software purchases) would more than double the effect on the product account of treating software as an investment good.

There is no direct way to determine whether estimates based on BEA's method are close to the actual figures, but several problems could make them over- or underestimates. For example, workers who actually develop software do not correspond exactly with workers in the occupations of computer programmer and computer systems analyst. Because those are the only two computer-related occupations in the Current Population Survey, they undoubtedly include many employees who spend at least part of their time doing things other than developing software—such as maintaining hardware, providing support services to computer users, or writing programs to carry out a one-time task. Likewise, workers in other occupations who develop software are not counted in that calculation—for example, "computer engineers" who are not included because they are grouped with "electrical and electronic engineers," or subject-matter specialists such as statisticians who develop statistical software.

A second problem is that some of the software developed in-house ends up embedded in durable equipment and so is already included as investment in the national accounts. Including the cost of developing that software would be double-counting. Workers employed in manufacturing industries that produce equipment account for about 20 percent of the 1995 estimate of in-house software investment.[15] If those workers develop only software to be embedded in equipment, the estimate should be reduced by 20 percent. However, some of those workers may create software that their company uses to produce equipment—such as software to control a production process or handle payroll—and its cost should be included in the in-house calculation.

Obviously, a great deal of uncertainty exists about the actual amount of in-house software investment, but nevertheless, it appears to be substantial compared with the amount of purchased software. Measuring the in-house component may be

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14. Those estimates are based on data from the Census Bureau's March 1995 Current Population Survey. Total wages are calculated using the product of estimated full-time, full-year employment and average earnings in the two occupations, excluding workers in the computer-services industries. That figure is multiplied by the ratio of total compensation to wages (1.22) from the NIPAs for 1995, and then by the ratio of combined operating expenses to combined payroll (1.92) for the prepackaged-software, computer programming services, and computer integrated system design industries.

15. The industries included are machinery, except electrical; electrical machinery, equipment, and supplies; motor vehicles and equipment; aircraft and parts; other transportation equipment; and professional and photographic equipment and watches.

particularly important in interpreting trends in software purchases. Firms appear to have shifted toward buying more software and producing less themselves, in which case business purchases of software are growing faster than total software investment. Thus, ignoring in-house investment leads to an understatement of software's contribution to investment and GDP, but it may lead to an overstatement of software's effect on measured growth rates.

PROGRESS TOWARD TREATING SOFTWARE SPENDING AS INVESTMENT

In its long-term plan for maintaining and improving the NIPAs, the Bureau of Economic Analysis proposes to expand the definition of investment to include spending on software. BEA and other government agencies have already taken some of the steps necessary to prepare for that change. For example, the U.S. classification system for foreign imports has been revised to provide for separate categories of computer software; that is a first step in developing estimates of the full market value of software imports. In addition, BEA is starting to estimate what portion of business purchases of software are treated as investment on tax returns, so it can improve the way corporate profits are adjusted in the income account to make that consistent with current NIPA methodology.[16]

BEA is also studying the feasibility of collecting data on businesses' software purchases and in-house software development. Collecting such data is likely to be particularly difficult given that current financial accounting standards do not require firms to capitalize all purchases and in-house production of software.

Both BEA and the Bureau of Labor Statistics (BLS) are working on price indexes for software. The BLS introduced such an index in February as part of the producer price index; it covers changes in the price of software produced by the prepackaged-software industry. The BLS plans to use hedonic models (which estimate the relationship between the prices and attributes of goods) to adjust for quality changes as new software is introduced. BEA's work focuses on developing a price index for custom-designed software, a category that presents difficult conceptual issues. BEA is also working on producing historical estimates based on the BLS price index.

The estimates of software spending in this analysis represent around 1 percent to 2 percent of GDP, so incorporating software into the national accounts would do little to change the measured size of the U.S. economy. However, it could be more

16. Parker and Seskin, "Annual Revision of the National Income and Product Accounts," p. 19.

important for some other statistics that help people understand the current state of the economy and its likely future—such as the real rate of economic growth and various measures of investment. To know whether that would be the case requires better information on the rate at which software prices are changing and on the extent of in-house software investment.

APPENDIX: HOW CBO CONSTRUCTED ITS ESTIMATES

The primary source of data for this analysis was the Census Bureau's Service Annual Survey, which estimates receipts by industry for most service industries, including those that produce software. Data from that survey are available for 1984 to 1995, though the information on software-producing industries is less detailed before 1990. Total receipts from that survey were adjusted based on a variety of other sources to come up with annual estimates of business and government purchases of software.

The Congressional Budget Office (CBO) estimates that businesses bought $46.9 billion worth of software in 1995 (shown as an adjustment to gross private domestic investment in Table 4) and that the value of depreciation on government-owned software in 1995 was $4.1 billion (shown as an adjustment to government expenditures). Business purchases were estimated using data from only that year, but the depreciation estimate was based on both current and past government software purchases. Likewise, the estimated effects on the capital stock, shown in Table 5, were based on estimates of business purchases for 1995 and many prior years, along with depreciation on those purchases.

Estimates of Business Purchases of Software

Figures in the national income and product accounts (NIPAs) for business purchases of investment goods are generally based on surveys that measure manufacturers' shipments of those goods to businesses rather than on businesses' reported spending.[1] CBO's analysis took a similar approach for software purchases by using information from producers. First, it estimated total receipts from sales of software. Then, to derive purchases by U.S. businesses, it adjusted that total for three categories of buyer: consumers, nonresidents (representing foreign trade), and governments. Finally, it deducted an estimate of the receipts that result from sales of software embedded in hardware, because those sales are already included in measured investment.[2]

1. For details of the sources used to prepare the NIPAs, see "Updated Summary NIPA Methodologies," *Survey of Current Business* (September 1997), pp. 12-33.

2. That method neglects a few other adjustments that would normally be made to derive estimates of business purchases of a good. Those other adjustments are changes in the inventory of software held by wholesalers and retailers, intermediate purchases (software purchased from one software producer by another and then resold as a component of either another software product or an integrated system), and trade and transportation costs (to value software at purchasers' prices rather than producers' prices). Changes in inventory could either increase or decrease the total but are likely to be relatively small. Neglecting intermediate purchases leads to an overstatement of total purchases because the value of such purchases is effectively counted twice in industry receipts. By contrast, neglecting trade and transportation costs leads to an understatement of total purchases (because adding them in would increase the value of business purchases).

Total Software Receipts. Three computer-services industries in the Service Annual Survey produce output that includes substantial amounts of software.

- "Prepackaged software" had receipts totaling $31.1 billion in 1995, the most recent year for which data are available.

- "Computer programming services" had total receipts of $37.4 billion in 1995. According to the government's Standard Industrial Classification, establishments in that industry engage "in providing computer programming services on a contract or fee basis . . . [and] perform a variety of additional services, such as computer software design and analysis; modifications of custom software; and training in the use of custom software."[3]

- "Computer integrated systems design" had total receipts of $20.6 billion in 1995. That industry is made up of "establishments primarily engaged in developing or modifying computer software and packaging or bundling the software with purchased computer hardware to create and market an integrated system for specific application."[4] Thus, that industry too produces customized software, but some of its receipts are accounted for by sales of hardware.

Firms are classified into industries based on their primary activity, but some of the receipts going to firms in a software industry may come from other activities. For example, in each of the industries listed above, some small portion of receipts comes from hardware installation and data processing. CBO reduced total industry receipts to take those other activities into account by using detail on specific sources of receipts from the Census Bureau's 1992 Economic Census of Service Industries. Three receipt categories in that survey appear to correspond closely to sales of software. Using those categories, CBO concluded that most of the receipts in the prepackaged-software and computer integrated systems design industries come from sales of software or integrated systems, whereas about half of the receipts in the computer programming services industry come from those sources (see Table A-1). For the latter industry, the most substantial category that was excluded was custom programming services other than custom software development.

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3. Office of Management and Budget, *Standard Industrial Classification Manual: 1987*, p. 365.

4. Ibid., pp. 365-366.

TABLE A-1. SOFTWARE SALES AS A PERCENTAGE OF RECEIPTS FOR THREE COMPUTER-SERVICES INDUSTRIES, 1992

	Industries		
Source of Receipts	Prepackaged Software	Computer Programming Services	Computer Integrated Systems Design
Sales of Prepackaged Software	87.3	3.2	0.9
Custom Software-Development Services	2.2	53.2	4.0
Sales or Lease of Integrated Systems	0.4	1.2	79.0
Total	89.9	57.6	83.9

SOURCE: Congressional Budget Office based on data from the Census Bureau.

For 1992, CBO's analysis simply added up receipts in those three categories for the three industries to estimate total software purchases. For other years, it used the 1992 percentages (89.9 percent of "prepackaged software" receipts, plus 83.9 percent of "computer integrated systems design" receipts, and 57.6 percent of "computer programming services" receipts), thus implicitly assuming that the composition of receipts for those three industries has remained approximately the same in recent years. For 1995, that calculation produced an estimate of $66.8 billion in total software receipts.

The Service Annual Survey includes six other computer-services industries that were not part of CBO's calculation. In 1992, the three receipt categories in Table A-1 accounted for $1.6 billion of receipts for those industries. For CBO's method to produce conservative estimates, the portion of integrated-system revenues that represents sales of hardware rather than software must be less than or equal to those software sales that were excluded from the calculation. Based on total 1992 integrated-system receipts of $12.4 billion, hardware sales must not account for more than 13 percent of receipts from sales of integrated systems.

Adjustments to Total Software Receipts. After estimating total software receipts for a given year, CBO subtracted four amounts to arrive at an estimate of software purchases by U.S. businesses that excludes embedded software.

Consumer Purchases. No estimates of consumer spending on software are regularly published, but the available evidence suggests that consumer purchases account for a small portion of total software receipts. In 1992, consumer spending on "computer software and accessories" amounted to $0.9 billion, according to data from the Bureau of Labor Statistics' Consumer Expenditure Survey.[5] Daniel Sichel estimates such spending at $1.5 billion in 1993, based on the assumption that consumers account for the same fraction of purchases of prepackaged software as they do for purchases of computers and peripheral equipment.[6] Consumers generally buy software for personal computers (PCs), so growth in consumer software spending is likely to parallel growth in the PC segment of the software market more closely than growth in the software industry as a whole. Sichel's estimate amounts to 24 percent of 1993 sales of PC-applications software, whereas the estimate from the Consumer Expenditure Survey equals 16 percent of 1992 sales of such software.[7] CBO's analysis uses the larger of those two percentages (out of a desire to err on the conservative side rather than a preference for Sichel's method) to estimate consumer purchases. Multiplied by sales of PC-applications software in 1995, the result is an estimate of $1.8 billion in consumer spending on software.

Nonresident Purchases. A survey by the Bureau of Economic Analysis provides data on imports and exports of various computer-related services. However, the industry classification scheme used in that survey (in the years for which data are currently available) is not as detailed as the classification scheme for industry receipts. Net exports in the category that would include all three of the industries listed above (plus several other computer-services industries) totaled $2.4 billion in 1995. CBO used that figure to adjust total software receipts for purchases by nonresidents.

Government Purchases. According to the 1992 Economic Census of Service Industries, federal, state, and local governments combined accounted for 8 percent of receipts in the prepackaged-software industry, 32 percent in the computer programming services industry, and 26 percent in the computer integrated systems design industry. CBO's analysis adjusted for government purchases by assuming that those fractions are constant over time and simply subtracting those shares from the

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5. Robert Parker, "Estimation of Investment in Computer Software" (paper presented at the OECD-UNECE-EUROSTAT Meeting of National Accounts Experts, June 1997).

6. Daniel E. Sichel, *The Computer Revolution: An Economic Perspective* (Washington, D.C.: Brookings Institution, 1997), pp. 61-62.

7. Data on sales of PC-applications software are taken from Software Publishers Association, *Software Sales Report, 1995* (available at http://www.spa.org/research/releases/histna95.htm). Those sales are measured at their retail value and so include transportation and trade costs that are not included in total software purchases.

software receipts of the three industries to get private purchases.[8] (The assumption that government purchases are a constant fraction over time may understate private purchases since 1992, however, since governments' share of equipment purchases in general fell from 18.0 percent in 1992 to 12.6 percent in 1995.) The estimate of government software purchases based on those shares totals $13.6 billion for 1995, with the federal government accounting for $11.1 billion of that figure.

Embedded Software. As discussed earlier, the NIPA estimate of producers' purchases of durable equipment includes the value of software that is embedded in hardware, such as personal computers, cellular phones, and fax machines. Since that component of software purchases already contributes to investment and GDP, it would be double-counting to include it in this calculation as well. The largest source of sales of embedded software would seem to be the licensing of Microsoft products to manufacturers of PCs. Microsoft reported 1995 revenues of $2.1 billion from licensing its products to manufacturers of original equipment. CBO subtracted that amount from software receipts to adjust for double-counting.

Double-counting is only an issue for software produced by firms in the software industries. The value of software made by firms whose primary activity is to produce hardware (and so whose industry classification is based on hardware production) is not included in total software receipts. Thus, it does not need to be subtracted from them.

Estimated Business Purchases. Adjusting total 1995 software receipts for government and consumer purchases, net exports, and the value of software embedded in hardware produces the estimate of $46.9 billion in business purchases of software shown in Table 4. As a point of comparison, business purchases of computers and peripheral equipment totaled $65.6 billion in 1995. Two other estimates of business software purchases, using similar but not identical methods, have come up with reasonably similar figures. A BEA paper gives an initial estimate of $33.9 billion for 1992, and Sichel estimates $35.2 billion for 1993, compared with estimates of $33.1 billion for 1992 and $37.5 billion for 1993 from applying the methods described here to data for those years.[9]

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8. So, for example, private purchases of software from the prepackaged-software industry are assumed to be 82.6 percent of the industry's receipts, derived by multiplying 89.9 percent (the share of receipts from software) by 92 percent (the share of receipts from nongovernment clients).

9. See Parker, "Estimation of Investment in Computer Software"; and Sichel, *The Computer Revolution*. The largest difference between the methods used in those studies and CBO's method is that the studies exclude the computer integrated systems design industry but include all receipts from the computer programming services and prepackaged-software industries.

Estimating the Change in Government Expenditures

Treating software as an investment good also involves estimating depreciation of the stock of government-owned software as a way to measure the value of services flowing from that software. Because that estimate is based on depreciation of a stock, it requires additional information: government software purchases from previous years, a price index to translate the value of purchases from earlier years into current terms, and a depreciation schedule. For 1990 to 1995, CBO estimated government software purchases using the same information and assumptions discussed above in making an adjustment for government purchases to derive business purchases. Receipts for the three industries are available separately only from 1990 onward, but combined receipts are available for 1984 through 1989. For those years, government software purchases were assumed to be 15.4 percent of receipts for the three industries combined, based on the government share in 1992. For years before 1984, no data on receipts are available, so government software purchases were extrapolated backward based on the average growth rate in industry receipts over the 1984-1995 period (15 percent).

No explicit information exists about depreciation rates for software, and only limited and somewhat inconsistent information is available about rates of price change, so CBO's analysis considered a range of possibilities.

Rates of Price Change. Several researchers have computed price indexes for software. Each found that prices have generally fallen, but their estimates give a wide range for the rate of decline: from about 3 percent to 15 percent a year.[10] CBO's analysis included calculations for the two extremes of that range, assuming a constant rate of decline. The faster the fall in prices, the less a given dollar investment in an earlier year is worth today, and hence, the lower the value of depreciation of government software assets. Thus, the 15 percent rate of decline results in a smaller increase in government expenditures and in GDP than the 3 percent rate does.

Depreciation Schedules. In the absence of any information on depreciation that is specific to software, the analysis used several alternative depreciation schedules. BEA defines depreciation as "the decline in value due to wear and tear, obsolescence,

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10. Stephen Oliner and Daniel Sichel, "Computers and Output Growth Revisited: How Big Is the Puzzle?" *Brookings Papers on Economic Activity,* no. 2 (1994), p. 300, found an average rate of decline of 2.7 percent for PC-applications software in general, with a rate of 4 percent for spreadsheets. Neil Gandal, "Hedonic Price Indexes for Spreadsheets and an Empirical Test for Network Externalities," *RAND Journal of Economics,* vol. 25, no. 1 (Spring 1994), p.168, found an average rate of decline of 15 percent for spreadsheets. Gandal's estimate used a hedonic approach to adjusting for quality change, but Oliner and Sichel used a process of matching models across years and using price changes only for models that could be matched. Both of those studies used data from the late 1980s and early 1990s; differences in the exact time periods covered do not seem to account for the different findings.

accidental damage, and aging."[11] For most types of investment goods, BEA now uses a geometric rate of depreciation in which the value of an investment good is assumed to decline by some fixed percentage each year. For computers and peripheral equipment, however, BEA uses rates based on studies of the selling prices of used IBM mainframes and computer peripherals. For software, most of the decline in value probably results from obsolescence rather than factors such as wear and tear, and obsolescence of software may be linked to obsolescence of the computer that runs it. For that reason, CBO's analysis used a computer depreciation schedule from BEA as one of its several possibilities for software depreciation.

Figure A-1 shows the depreciation schedules that BEA uses for PCs and recent mainframes, along with two schedules based on geometric rates of depreciation. The higher geometric rate, 55 percent, corresponds to an average service life of three years (based on the three-year service life used for software in the tax code). At that rate, only 9 percent of the original value of an investment remains after three years of service.[12] The lower rate (16.5 percent) corresponds to an average service life of 10 years, which was chosen to allow for the possibility that software retains value over a long period of time.[13] That possibility seems to be relevant for at least some software, given current concern about the ability of old software to deal with dates after the year 2000. Faster rates of depreciation translate into larger estimates of government consumption of capital. The figure for govern-

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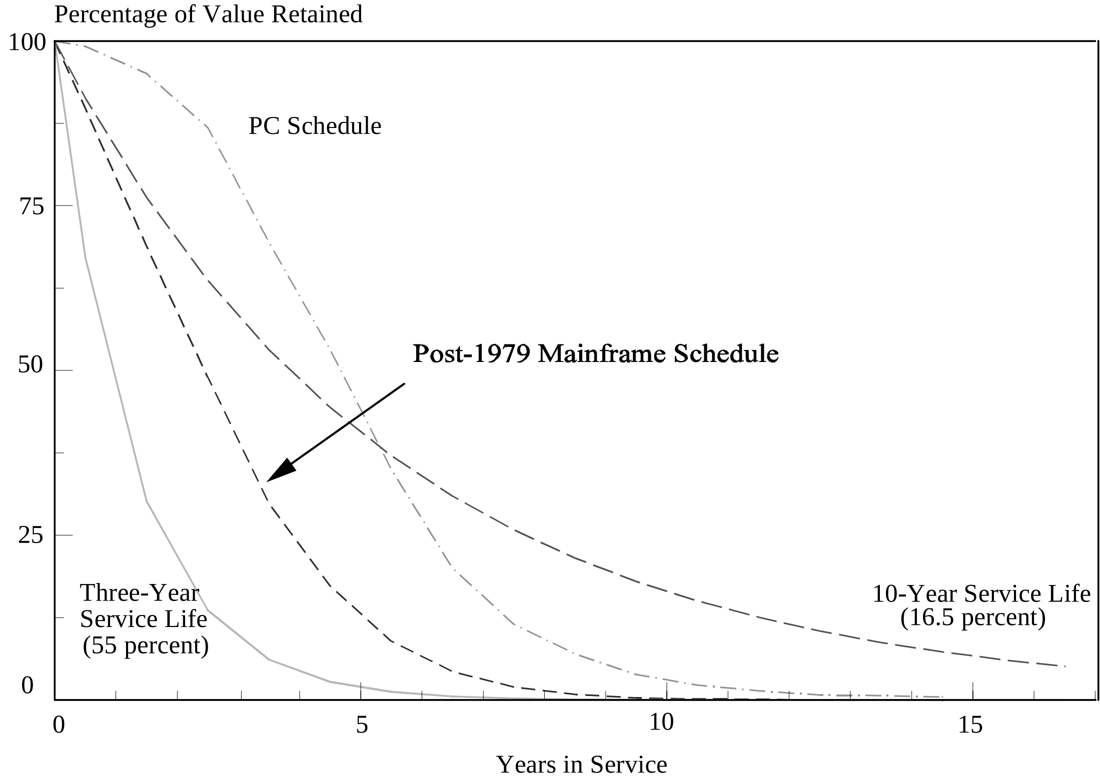
11. Arnold Katz and Shelby Herman, "Improved Estimates of Fixed Reproducible Tangible Wealth: 1929-1995," *Survey of Current Business* (May 1997), p.70.

12. Most geometric rates of depreciation used in the national accounts are based on estimates of average service lives combined with a declining balance rate to obtain the annual percentage decline in an asset's value. The particular rates used in this analysis are based on the standard declining balance rate for producers' equipment in the NIPAs (1.65). The rate of depreciation is the declining balance rate divided by the service life, so for a three-year average service life, the rate of depreciation is 1.65/3, or 0.55. Note that this is not identical to the straight-line depreciation used for tax purposes, under which one-third of the original value would be depreciated each year, leaving no value after three years. With a geometric rate of depreciation, 45 percent of the value of the investment remains after one year, 20 percent [0.45x(1-0.55)] after two years, and 9 percent [0.45x(1-0.55)x(1-0.55)] after three years.

13. With a 10-year service life, an investment retains 58 percent of its value after three years and 16 percent after 10 years. Because the mainframe and PC depreciation schedules are based directly on estimates of resale prices of used computers, neither conforms exactly to a schedule with a constant annual rate of depreciation that can be characterized by an average service life. Both, in fact, involve rates of depreciation that increase over the life of an investment. Despite that, the mainframe schedule does not differ dramatically from the depreciation pattern for equipment with a five-year average service life, although a mainframe investment retains somewhat more of its value over the first three years, and less after that, than would an investment described by the five-year-service-life schedule. The PC schedule has a rate of depreciation of about 4 percent the first year, but the annual rates then rise rapidly, to about 40 percent per year after six years. Its shape does not come close to any schedule with a constant rate of depreciation.

FIGURE A-1. COMPARISON OF ALTERNATIVE DEPRECIATION SCHEDULES



SOURCE: Congressional Budget Office based on information from the Bureau of Economic Analysis.

NOTE: PC = personal computer.

ment expenditures in Table 4 is based on the PC depreciation schedule, which produces the lowest estimate among the schedules in CBO's analysis. Given that the PC and 10-year schedules cross, either could potentially give a lower estimate, but in practice the PC schedule does so.

Estimated Depreciation of Government-Owned Software. Using the three-year-service-life and PC schedules generates a range of $4.1 billion to $9.9 billion with a 15 percent deflation rate and $6.8 billion to $11.4 billion with a 3 percent deflation rate. With the 10-year-service-life schedule, extrapolation of software purchases for the years before 1984 could potentially have some effect on the estimates; but because deflation reduces the effects of purchases from earlier years, the growth rate before 1984 had a negligible effect on the estimates as long as it was assumed to be positive.

Factoring Software Into Real GDP Growth

For the chain-type measure of real output now used in the national accounts, the ratio of real GDP in 1995 to its value in 1994 is

$$Q_{95} = \sqrt{\frac{\sum p_{95}q_{95}}{\sum p_{94}q_{94}} \frac{\sum p_{94}q_{95}}{\sum p_{95}q_{94}}}$$

where *p* and *q* represent the prices and quantities, respectively, of the goods that make up GDP. The first term under the square root sign is the ratio of nominal GDP in 1995 to that in 1994. The value of that term when software is included equals the nominal value of the software components plus the nominal value of GDP in each year.

Values for the numerator and denominator of the second term are not published, but their ratio (excluding software) can be derived from the relationship between indexes for real and nominal GDP in the national accounts. Adjusting that ratio to include software requires having a value for either the numerator or denominator. The denominator corresponds to the value in 1995 prices of the goods that made up GDP in 1994. For the calculations in CBO's analysis, that value is approximated by inflating 1994 nominal GDP using the 2.54 percent rate of price change implied by the chain-type price index for GDP. In general, that price index will not give precisely the right rate of inflation for the calculation in question, but the rate would have to be off by more than 2 percentage points to have any effect on the adjustment to the real growth rate.

Estimating the Software Capital Stock

Estimating software's contribution to the private capital stock requires essentially the same sort of information as estimating depreciation of the stock of government-owned software: purchases in previous years, rates of price change, and a depreciation schedule. CBO used the same assumptions about depreciation and rates of price change for the software capital stock as it did for depreciation of government software.

To estimate private-sector purchases of software in previous years, CBO followed the method described for the product account when similar data were available and extrapolated values for early years when data were not available. As mentioned above, receipts for the three computer-services industries in CBO's analysis were available separately only from 1990 onward. For 1984 through 1989, private-sector software purchases were assumed to be 58.4 percent of combined receipts for the three industries—the 1992 fraction of combined receipts. For years before 1984, private purchases were extrapolated by assuming that they grew at a rate of 15 percent, the growth rate of combined receipts over the 1984-1995 period.

Business purchases equal private-sector purchases minus consumer purchases and net exports. Consumer purchases were assumed to equal 24 percent of sales of PC-applications software in 1987 through 1995. For years before 1987, which lack data on sales of that type of software, consumer purchases were extrapolated backward assuming a 26 percent annual rate of growth (the rate of growth of such sales over the 1987-1990 period).

When a three-year average service life is assumed, only the data from 1990 and later matter for estimates of the capital stock. Even with a 10-year average service life, the assumptions used to extrapolate to fill in missing data have little importance—filled-in values from before 1984 account for just 0.9 percent of the estimated stock with a 3 percent deflation rate, and 0.2 percent of the estimated stock with a 15 percent deflation rate.