

Recognition of Business and Government Expenditures for Software as Investment: Methodology and Quantitative Impacts, 1959-98

The comprehensive benchmark revision of the national income and product accounts (NIPA's), released in October of last year, newly recognized business and government expenditures for computer software as investment. This paper describes the methodology for annual and quarterly estimates of software investment, consumption of fixed capital, and business incomes. This description is an expansion of the technical notes describing the methodology that appeared in the August and December issues of the Survey of Current Business. The paper also describes the effects on the NIPA's and their tabular presentation, of recognizing software.

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One of the most important changes to the National Income and Product Accounts (NIPA's) in the recently-released comprehensive benchmark revision is the recognition of business and government expenditures for computer software as investment.¹ Previously, only software embedded in equipment by the producer of that equipment was counted as investment. Business expenditures for software were classified as inputs to production, and government expenditures for software were classified as government consumption expenditures.

This paper presents: A description of the various types of software; an overview of the impacts of the recognition of software as investment in current dollars, prices, real software, and real GDP; a summary discussion of the effects of software on the definitions of NIPA components; a listing of changes in NIPA tables due to the new treatment of software; and a list of planned future improvements. The methodology used to estimate software is provided in an appendix, which expands on the descriptions that appeared in the August and December issues of the Survey of Current Business.

1. Computer software

Three types of software are newly treated as investment. These are: (1) prepackaged software; (2) custom software; and (3) own-account software.

Prepackaged software is software intended for nonspecialized uses and is sold or licensed in standardized form. It typically requires little or no modification for use. It includes both systems software and applications software. Prepackaged software is available in a number of forms, ranging from pre-wrapped boxes to electronic files that may be downloaded from the Internet. The large majority of producers of prepackaged software were previously classified in SIC 7372 (prepackaged software) and are now classified in NAICS 51121 (software publishers) or NAICS 334611 (software reproducing).

Custom software is software tailored to the specifications of a business enterprise or government unit. It may include new computer programs as well as programs incorporating preexisting or standardized modules. Expenditures for custom software include those for the development (analysis, design, and programming) of software tailored to the business enterprise's or government unit's specifications. The expenditures include payments to free-lance computer software writers and to consulting organizations and individuals, who are not employees, who perform programming and systems analysis to support the development of software. It also

¹ A description of the revision, including the effects of recognizing software as investment, may be found in Eugene Seskin, "Improved Estimates of the NIPA's for 1959-98: Results of the Comprehensive Revision," Survey of Current Business 79 (December 1999): 15-39.

includes expenditures on tailored software that is modified by providers of software or computerized equipment. The large majority of producers of custom software were previously classified in SIC 7371 (computer programming services) and are now classified in NAICS 541511 (custom computer programming services).

Own-account software consists of in-house expenditures for new or significantly-enhanced software created by business enterprises or government units for their own use. These expenditures include: Wages, salaries, and related compensation (such as contributions to pensions and for FICA), materials and supplies consumed, and indirect costs. The indirect costs include depreciation of plant and equipment, utilities, travel, property and other taxes, maintenance and repair of plant and equipment, and overhead--including personnel, accounting, and procurement. The expenditures are made for analysis, design, programming, and testing of software and may be made by any industry.

Software-related expenditures treated as investment exclude maintenance and repair expenditures on existing software, including expenditures to fix so-called "Y2K" problems. In addition, in-house expenditures on software that is to be embedded in computers and other equipment that is to be sold are excluded from software investment in order to avoid double-counting.²

2. Quantitative impact of the new treatment

Current-dollar software investment—Software investment by business and government increased rapidly from very small amounts in the late 1950's to \$1 billion in 1966. It continued to grow rapidly, to more than \$10 billion beginning in 1979, and to \$159 billion in 1998. The growth rates have been very large, but have diminished gradually over time.

Average annual rates of growth for current-dollar software

1959-98	26.4 percent
1959-92	29.2 percent
1959-79	38.7 percent
1979-92	15.7 percent
1992-98	12.3 percent

All three types of software investment have grown rapidly since 1970 (chart 1). During this period, prepackaged software, which has the smallest share, has grown most rapidly and has increased its share from about 8 percent of total software in the 1970's to 26 percent in 1998. Custom software's share has decreased slightly, from about 42 percent in the 1970's to 40 percent

² In-house expenditures on software for mineral exploration and development, which is treated as investment, are also excluded.

in 1998. The share of own-account software has gradually decreased from nearly 50 percent in the 1970's to 34 percent in 1998.

Average annual rates of growth for current-dollar software
(Percent change)

<u>Period</u>	<u>Prepackaged</u>	<u>Custom</u>	<u>Own-account</u>
1959-98/1/	29.2	28.2	27.0
1959-92	32.6	30.4	23.8
1959-79	38.4	42.3	36.1
1979-92	25.1	14.0	14.2
1992-98	13.5	16.6	7.7

1. Estimates for prepackaged software begin with 1962.

Expenditures for the three types of software have followed very different patterns for business and for government. Business expenditures for own-account software have had the largest share of the total, but have experienced slower growth (chart 2). Expenditures for custom software slowed in the early 1990's before beginning to increase more rapidly: They are nearly as large as expenditures for own-account software in 1998. Business expenditures for prepackaged software increased at the same rate as the other two types in the 1970's, and have grown more rapidly thereafter. Reflecting these patterns, the share of prepackaged software in total business expenditures has increased rapidly since 1980, largely matched by declining shares of custom software, and own-account software.

Government expenditures for own-account software increased rapidly until the late 1980's, and much more slowly thereafter (chart 3). Government expenditures for custom software grew at about the same rate as all government expenditures for software until the late 1980's, and have increased much more rapidly since then. Since the mid-1970's, expenditures for prepackaged software have increased steadily, at rates somewhat more rapid than overall government software expenditures.

Software prices--Price indexes for the various types of software have had very different time patterns. Generally, prices for prepackaged software have fallen sharply, prices for business and government own-account software have increased steadily, and prices for custom software have shown little trend, increasing modestly until the mid-1980's, and fluctuating in a narrow band thereafter (chart 4).

Average annual rates of change for software prices
(Percent change)

<u>Period</u>	<u>Prepackaged</u>	<u>Custom</u>	<u>Own-account</u>	
			<u>Business</u>	<u>Government</u>
1959-98/1/	-10.1	0.4	4.1	4.7
1959-92	-10.7	0.5	4.5	5.1
1959-79	-10.5	0.2	5.4	5.2
1979-92	-11.0	1.1	5.0	5.0
1992-98	-6.8	-0.2	2.0	2.9

1. Estimates for prepackaged software begin with 1962.

The declines in prices of prepackaged software appear to reflect economies of scale, with many more units of specific programs having been sold with passing time as, in particular, the numbers of personal computers in business use have increased. Own-account software prices are driven by employee compensation costs and the costs of intermediate products consumed. It is assumed that there are no economies of scale and little chance for improvements from learning curves because each own-account computer program tends to be a one-shot effort. As measured by BEA, custom software's prices reflect both the declining prices of prepackaged software that is often incorporated as well as the labor and intermediate input costs incurred in producing unique software systems.

Real software investment--Real software investment, at the most detailed level, is derived by deflation, or dividing current-dollar investment flows by price indexes. Real software investment is calculated separately for each of the three types of software within business investment and within each of 5 categories of Federal and State and local government software investment.³ In total, there are 18 detailed levels. Aggregate measures of software, such as all business or all Federal government software are calculated using the Fisher chain-type quantity index.

As with current-dollar software investment, real software investment by business and government increased rapidly from very small amounts in the early 1960's. The growth rates have been very large, but have diminished gradually over time:

³ The categories are Federal defense, Federal nondefense, Federal government enterprises, State and local general government, and State and local government enterprise.

Average annual rates
of growth for real software

1959-98	24.6 percent
1959-92	26.8 percent
1959-79	31.1 percent
1979-92	15.9 percent
1992-98	13.4 percent

All three types of real software have grown rapidly throughout the period covered by the software estimates.

Average annual rates of growth for real software, by type
(Percent change)

<u>Period</u>	<u>Prepackaged</u>	<u>Custom</u>	<u>Own-account</u>
1959-98/1/	39.5	27.5	18.8
1959-92	42.9	29.5	21.4
1959-79	55.2	42.0	30.4
1979-92	40.6	12.9	8.7
1992-98	22.2	16.8	5.4

1. Estimates for prepackaged software begin with 1962.

As with current-dollar software investment, real expenditures for the three types of software have followed very different patterns for business and for government. Real business expenditures for own-account software increased in every year since 1970 except 1971 and 1977 (chart 5). Real business expenditures for custom software slowed slightly between 1989 and 1992, and increased more rapidly thereafter. Real business expenditures for prepackaged software, which were negligible until the mid-1980's, nevertheless have increased rapidly in percentage terms since 1970.

Real government expenditures for the three types of software have generally grown steadily since 1970. Since the late-1980's, however, real government expenditures for own-account software have grown only slowly or declined (chart 6). Real government expenditures for custom software increased especially rapidly after 1987. Real expenditures for prepackaged software, which were negligible until the mid-1980's, nevertheless have increased rapidly in percentage terms since 1970.

Real GDP.--The revised treatment of software has increased the rate of growth in real GDP beginning with the first year for software estimates, 1959. Beginning in the mid 1980's, the increases have grown substantially. Although the rate of growth of real software investment has

slowed in recent years, its largest effects have been in the 1990's. In the decade 1989-98, software has accounted for 0.15 to 0.20 percentage points of the average rate of growth of real GDP (chart 7 and table 1 show the effects of final sales of software on GDP).⁴

Business (Private) Net Stocks of Software.—Private net stocks have grown rapidly over time, mirroring the pattern of private software investment. Because software has service lives that are short in comparison to most other types of fixed investment, the relative size of software stocks to total private stocks is small in comparison to the size of software investment relative to total private investment. For example, in 1998 the ratio of current-cost private software stocks to total current-cost private stocks was 1.2 percent, whereas the ratio of private software investment to gross private fixed investment was 8.5 percent.

3. Changes to definitions of NIPA components

Table 2 identifies the changes to NIPA components resulting from the recognition of software as investment. Among the components of GDP, personal consumption expenditures (PCE) is affected because of the reclassification from consumption to investment of software purchases by nonprofit institutions serving individuals and the addition of the consumption of fixed capital (CFC) as an operating expense. Private fixed investment is increased because of the reclassification of software expenditures from intermediate consumption to investment for businesses and nonprofit institutions. For government, investment in software for general government agencies is reclassified from consumption expenditures to gross investment and investment for government enterprises is added. In addition, following the convention for all general government investment, the services of software, measured by depreciation, or CFC, is added to government consumption expenditures. Overall, GDP is increased by business expenditures for software in private fixed investment, and by software CFC of nonprofit institutions in PCE and of general government in government consumption expenditures.

Among the components of gross domestic income (GDI), CFC increases by the amount of the added software CFC for nonprofit institutions serving individuals, for private businesses, and for government. The current surplus of government enterprises is revised up by the reclassification of software investment from intermediate consumption to investment and by the addition of own-account software as a receipt, and revised down by the addition of the CFC as a deduction. Similarly, corporate profits before tax and proprietors' income are revised up by the reclassification of software investment and the addition of own-account software. They are

⁴ These impacts can be estimated in two ways. The first way measures the incremental effects of the revised treatment of software, which are equal to private software investment plus CFC of general government software. The second way measures the impact on GDP of all expenditures on software regardless of whether they were affected by the revised treatment of software. These expenditures make up final sales of software and include personal consumption expenditures for software, private software investment, net exports of software, and government software investment, but does not include CFC of general government software. The effects on real GDP growth estimated by the two ways are similar in size.

reduced by the amount of depreciation added as a deduction to these business incomes in the capital consumption allowance (CCA), which is the tax return based estimate. These two measures of depreciation differ because the CCA is calculated using historic prices whereas the CFC uses current-replacement prices. Finally, for corporate profits and proprietors' income, the capital consumption adjustment, which is equal to the difference between the CCA and CFC is revised. Overall, GDI is increased by expenditures for software by private businesses and government enterprises and by the software CFC of nonprofit institutions serving individuals and general government. Within business incomes and government enterprises surplus, there are smaller deductions from the reclassification of software.

4. Changes in NIPA tables

The recognition of business and government expenditures for software as fixed investment affects the presentation of several NIPA tables. The series for gross private domestic investment, private fixed investment, and government gross investment are redefined to include expenditures for software by business and government. In addition, government consumption expenditures is redefined to exclude expenditures for software and to include consumption of fixed capital for general government software as a partial measure of the services of the stock of government software. The producers' durable equipment component of nonresidential fixed investment is renamed "equipment and software," and the producers' durable equipment component of residential fixed investment is renamed "equipment." The equipment component of gross government investment is renamed "equipment and software," and the electronics component of national defense gross investment is renamed "electronics and software."

In the new presentation of private fixed investment, a new series, "software," is added to tables 5.4, 5.5, 5.8, 5.9, 7.6, 7.8, and 8.4. The new series are included in "information processing and related equipment," which is renamed "information processing equipment and software." The series "office, computing, and accounting machinery" is deleted from tables 5.8, 5.9, and 7.8.

As a result of the recognition of software as investment—specifically, the reclassification of own-account software production—the series name "compensation of general government employees, except force-account construction" is changed to "compensation of general government employees, except own-account investment" in tables 3.7, 3.8, 3.10, 3.11, 7.11, 7.12, and 8.6.

5. Future improvements

BEA plans future improvements to the estimates of software. Some will be in areas where additional work, new surveys, or additional supporting information—either from outside sources or from other BEA work, such as the upcoming 1997 input-output estimates and new questions on the Census Bureau's 1999 Annual Capital Expenditures Survey—will make improvements possible. Areas where BEA would like to make improvements include the following.

Current-dollar estimates:

- Update estimates of the share of own-account and custom software that is investment and not maintenance and repair expenditures.
- Update estimates of the shares of computer programmers' and systems analysts' time spent on own-account software investment versus other activities, including software intended for resale or embodiment in other capital goods..
- Separately identify imports and exports of e-sales of software and programming services.

Prices:

- Improve estimates of prices of custom software and prepackaged software (at present, estimates of prepackaged software prices are based on the BLS PPI for applications software with a BEA adjustment for quality improvements).
- Explore the introduction of labor productivity adjustments in the prices of own-account software (at present, no change in productivity is assumed).

Appendix: Estimation Methodology

A. Annual estimates

This section describes the methodologies that BEA has developed to prepare (1) annual estimates of business and government purchases of software, (2) annual estimates of own-account production of software, (3) price indexes that are needed to prepare the real estimates for both types of software, and (4) estimates of consumption of fixed capital and business incomes.

Current-dollar estimates

Purchased software.-- For 1987 and 1992, the estimates of business and government purchases of prepackaged software and custom software are based on estimates from the benchmark input-output (I-O) accounts. For other years, estimates are prepared using the commodity-flow method in which directly measured output is allocated among the various expenditure components, primarily using relationships from the benchmark I-O accounts.⁵ Table 3 shows the primary source data for the commodity flow estimates for 1960-98.

Table 4 contains additional information about the details of the commodity flow data and estimating methodology, and contains the commodity-flow estimates for the various stages of the computations for 1992. First, the estimates of the total output of purchased software are derived. Beginning with 1985, output is based on industry receipts data from the Census Bureau's service annual survey.⁶ For 1960-84, output is based on trade source data on revenues for software and computer services, and for 1959, output is estimated using a judgmental trend based on private computer purchases. Next, estimates of business purchases of software that is embedded in other equipment and of the change in business inventories of software are prepared using benchmark I-O relationships of these transactions to total output.⁷ These intermediate purchases and inventory changes are subtracted to obtain domestic supply to final uses. Next, net exports of software are derived, beginning with 1960, from data on trade in goods from the Census Bureau.⁸

⁵ For a description of these accounts, see U.S. Department of Commerce, Bureau of Economic Analysis, Benchmark Input-Output Tables of the United States, 1992 (Washington, DC: U.S. Government Printing Office, 1998). For a description of the commodity-flow method, see Benchmark Input-Output Tables, M-5.

⁶ Beginning with 1990, the receipts data are derived from data for the following two industries: Computer programming services (SIC industry 7371) and prepackaged software (SIC 7372). For 1985-89, the receipts data are derived from data for the computer and data processing services industry (SIC 737).

⁷ Annual estimates of software inventories are available only from the benchmark I-O tables. For the calculation of investment in prepackaged software, it is assumed that the inventory changes for all years except 1987 and 1992 are zero.

⁸ Estimates of royalties and license fees for custom software and prepackaged software distributed by non-physical means are in exports and imports of services estimates, but are not separately identifiable.

The net exports are subtracted to obtain supply to domestic final uses. Next, estimates of personal consumption expenditures (PCE) for software are derived, beginning with 1977. For 1977-91, these purchases are estimated using data from the Bureau of Labor Statistics (BLS) consumer expenditures survey; for 1992, these purchases are from the benchmark I-O table and are based on Census Bureau retail sales and services receipts from the 1992 Economic Censuses; and beginning with 1993, these purchases are based on data from the Census Bureau's retail trade surveys.⁹ The PCE is subtracted to obtain total software investment. Finally, the total investment estimates are divided between business purchases and government purchases, using benchmark I-O relationships of business purchases and of government purchases to total investment, and further detail is calculated within government investment using both I-O and other information.

Own-account software.—Own-account software expenditures are not separately identified in the input-output accounts because they appear as part of total intermediate inputs and compensation of employees. As a result, the commodity-flow methodology cannot be used. Newly developed estimates have been prepared to measure this type of investment in software.¹⁰ Own-account production of software is measured as the sum of production costs; in general, these costs consist of the following: Intermediate inputs; factor incomes, such as compensation of employees; nonfactor charges, such as indirect business taxes; and CFC. Because of the lack of available source data, these costs are limited to intermediate inputs and compensation of employees.

Table 5 shows the primary source data and methods for calculating own-account software investment. For 1985-96, total output of own-account software is calculated by multiplying the number of programmers and systems analysts in selected industries times a factor to account for the share of time spent doing tasks associated with software investment, times the median wage rate in those industries, times various factors that cover nonwage compensation costs and intermediate inputs. Data on the number of computer programmers and systems analysts by industry are then used to provide estimates of output for private employees, for Federal Government employees, and for State and local government employees.

Data on the number of programmers and systems analysts are available from BLS by occupation and by industry.¹¹ In order to avoid double-counting the work performed by some of these employees to create embedded software or to produce software for sale, an adjustment is made to the total number of programmers and systems analysts that reduces the number of

⁹ The estimates of PCE for software are unpublished detail underlying the NIPA estimates of PCE for durables.

¹⁰ Federal Government agencies provide data on obligations for information technology to the Office of Management and Budget; however, these data do not provide sufficient detail to estimate the costs that are solely related to own-account production.

¹¹ See Bureau of Labor Statistics, "Employment by Occupation and Industry, 1983-96" in the National Industry-Occupation Employment Matrix (unpublished).

employees from the mining, manufacturing, and business services industries. This adjustment is made judgmentally on the basis of unpublished BLS data on the employment of computer programmers and systems analysts as a share of all industry employment.

Data on the proportion of time spent by programmers and systems analysts on the development of new software are based on a private study, reported by Barry Boehm, of the share of software development and maintenance costs in 487 business organizations.¹² The detailed shares reported by Boehm are as follows. The categories that are included in software investment are in bold italics.

<i>Development</i>	<i>43 percent</i>
Maintenance:	
Emergency program fixes	6 percent
Routine debugging	4 percent
Accommodate changes to input data, files	8 percent
<i>Accommodate changes to hardware, operating systems</i>	<i>3 percent</i>
Enhancements for users:	
<i>New reports</i>	<i>8 percent</i>
<i>Added data for existing reports</i>	<i>6 percent</i>
Other	7 percent
Improve documentation	3 percent
<i>Improve code efficiency</i>	<i>2 percent</i>
Other	2 percent
Other	8 percent

Although the best point estimate of the share of time spent on investment is 62 percent, a 50 percent share was chosen to emphasize the approximate nature of the estimate. The 50-percent share is also based on anecdotal evidence that the share of programmers' time spent doing tasks associated with new software has diminished with the growing importance of personal computers and prepackaged software. So far, no recent study of programmer time spent on various tasks has been identified. The 50-percent share is believed to more accurately reflect the recent computer environment than does the Boehm study, which was for a mainframe environment. A single share was chosen to emphasize the plausible-but-arbitrary nature of the estimate.

Wages are derived from BLS data on median weekly earnings for computer programmers and systems analysts.¹³ The other production costs are derived as follows: Nonwage compensation, on the basis of the relationship between compensation and wages derived from

¹² Barry W. Boehm, Software Engineering Economics (Englewood Cliffs, NJ: Prentice-Hall, 1981): 533-35, 548-50.

¹³ See "Median Usual Weekly Earnings of Full-time Wage and Salary Workers by Detailed Occupation and Sex, 1996," Employment and Earnings (January 1998): table 39. The estimates in this table are based on data collected in the current population survey.

published NIPA data by industry;¹⁴ and intermediate inputs,¹⁵ on the basis of the relationship between intermediate inputs and compensation derived primarily from the Census Bureau's census of service industries.¹⁶

For years before 1985, this methodology is modified to reflect the availability of source data. For 1972-84, the modifications are as follows: Trade source data are used for the total number of programmers and systems analysts; the NIPA measure of wages and salaries per full-time equivalent employee for the business services industry (SIC 73) is used for the median wage rates of business; and price indexes for compensation of Federal nondefense employees and for compensation of State and local noneducation employees are used for median wage rates for government. For 1959-71, a different methodology is used; the business and the government estimates of own-account software production are extrapolated back using NIPA estimates of business purchases of computers and peripheral equipment. For 1997-98, business own-account software is extrapolated using NIPA estimates of private fixed investment in computers and peripheral equipment; government own-account software is extrapolated using NIPA Federal government gross investment in computers and peripheral equipment.

Prices

Currently, the information available on price indexes for prepackaged software is limited, and no price indexes are available for the prices of custom software or own-account software. Methodologies for estimating each of the price indexes have been developed by BEA. As described in this section, they vary depending on the information available to support the estimation process.

Prepackaged software.--Different methodologies are used to estimate the price index for prepackaged software in different time periods because the source data used do not cover the full 1959-98 period for which estimates are prepared. Table 6 shows the source data and the methodologies used. The price index is based on information from the following sources: a BEA hedonic price index for 1985-93 for business applications software; a BEA matched-model price index for selected types of prepackaged software, including spreadsheets, databases, and word processors for 1993-97; a matched-model price index for 1985-93 that is based on matched-model indexes for spreadsheet and word processing programs that were developed by Steven

¹⁴ See NIPA tables 6.2, 6.4, and 6.6.

¹⁵ The intermediate inputs include depreciation (which is a proxy for capital services), materials, rent, utilities, maintenance and repair, and general overhead.

¹⁶ The relationship is primarily based on data in the 1987 Census of Service Industries: Capital Expenditures, Depreciable Assets, and Operating Expenses (Washington, DC: U.S. Government Printing Office (GPO), 1991) and the 1992 Census of Service Industries: Capital Expenditures, Depreciable Assets, and Operating Expenses (Washington, DC: U.S. GPO, 1996).

Oliner and Daniel Sichel;¹⁷ and beginning with December 1997, a Bureau of Labor Statistics (BLS) producer price index (PPI) for all prepackaged applications software that is also based on prices of matched models.

For 1985-93, the quality-adjusted price index is estimated by combining the BEA-developed hedonic price indexes and the Oliner-Sichel matched-model indexes. BEA developed hedonic price indexes for two types of prepackaged software--spreadsheets and word processing.¹⁸ These hedonic price indexes are estimated using a methodology that is an extension of earlier work on software prices by Brynjolfsson and Kemerer and by Gandal.¹⁹ The price index estimates are based on regressions in which the logarithm of prices of prepackaged software is a function of selected quality characteristics and of dummy variables for each year of the price observations. The resulting indexes are "regression" price indexes in which the coefficients of the dummy variables for each year are used to construct price index values for the sample periods of the regressions.²⁰ The individual hedonic price indexes for the two types of software are weighted together equally to produce a summary hedonic price index for prepackaged software.

For 1985-93, the prepackaged software price index is estimated using an unweighted average of the percent changes in the matched-model index and the summary hedonic index. This approach reflects the concern that the hedonic index may overstate price declines because over time, the characteristics of high-priced packages with limited sales are incorporated into lower priced packages that have much greater sales. (This, in effect, gives too great a weight to the values derived from the high-priced packages.)

For 1994-97, source data to prepare hedonic indexes are not adequate, so BEA uses private source data on retail prices and quantities sold to develop a matched-model index that covers business-oriented software. This index extends the Oliner-Sichel-based matched-model index to 1997, and is based on a broader group of business-oriented prepackaged programs. In addition, an annual bias adjustment is made because it is likely--assuming less than complete

¹⁷ Steven Oliner and Daniel Sichel, "Computers and Output Growth Revisited: How Big Is the Puzzle," in Brookings Papers on Economic Activity vol. 2 (Washington, DC, 1994): 299-301.

¹⁸ The data on prices and quality characteristics used to estimate the regressions are obtained from published editions of National Software Testing Laboratories' Ratings Reports. These data are available only until 1994. Hedonic estimates were also made for database software, but the results were not adequate to support the estimation of a price index.

¹⁹ Eric Brynjolfsson and Chris F. Kemerer, "Network Externalities in Microcomputer Software: An Econometric Analysis of the Spreadsheet Market," Management Science, 42 (1996), 1627-47, and Neil Gandal, "Hedonic Price Indexes for Spreadsheets and an Empirical Test for Network Externalities," Rand Journal of Economics vol. 25, no. 1 (Spring 1994): 164-70.

²⁰ For a discussion of the construction of quality-adjusted price indexes using hedonic methods, see Roseanne Cole et al., "Quality-Adjusted Price Indexes for Computer Processors and Selected Peripheral Equipment," Survey of Current Business 66 (January 1986): 41-50.

market equilibrium--that the matched-model indexes understate quality-adjusted price declines; quality improvements, such as enhanced power and performance, tend to be introduced in new versions of software, so they are not captured by the matched-model estimates. The bias adjustment is equal to one-half the 6.3-percent per year difference between the matched-model index and BEA's averaged index for 1985-93.

For 1998, the BLS PPI for all applications software is used, also with the bias adjustment. The BLS index is linked to a monthly version of the BEA matched-model price index in December 1997.

The price index for prepackaged software is extended back prior to 1985 using an indicator series that is equal to 60 percent of the annual change in the NIPA price index for computers and peripherals. This percentage corresponds to the average difference for 1985-97 in the annual rates of change in the computer and peripherals price index and the annual rates of change in the prepackaged software price index.

Table 7 shows percentage changes in the prepackaged software price index for 1986-98 and the hedonic and matched-model price indexes used in its derivation.

Own-account software.--The price indexes for own-account software investment are input-cost indexes that are calculated from a weighted average of compensation rates for computer programmers and systems analysts and the intermediate inputs associated with their work.²¹ (These intermediate input costs vary somewhat, but they average slightly more than half the total costs.) It is assumed that there are no changes in the productivity of computer programmers and systems analysts. Compensation cost indexes are estimated separately for government and for business own-account software investment because the compensation rates for computer programmers and systems analysts in the two sectors have moved somewhat differently over time. Table 8 provides an overview of the methodologies and data sources for the own-account price indexes.

For 1972-96, chain-weighted indexes of input costs are calculated using estimates of compensation of programmers, compensation of systems analysts, and intermediate inputs. The business sector compensation rates for 1987-96 are based on BLS estimates of median usual weekly earnings for programmers and systems analysts; for 1972-86, they are based on NIPA estimates of wages and salaries per full-time equivalent employee in the business services industry (which includes producers of the overwhelming majority of prepackaged and custom software). The government sector compensation rates are derived from the NIPA price indexes for Federal

²¹ The price index estimates for business own-account software mirror the estimation process for current-dollar software expenditures, which begins with wage rates for, and numbers of, computer programmers and systems analysts. For a more complete discussion of the current-dollar estimates, see Brent Moulton, Robert Parker, and Eugene Seskin, "A Preview of the 1999 Comprehensive Revision of the National Income and Product Accounts: Definitional and Classificational Changes," *Survey*, 79 (August, 1999) pp. 7-20.

nondefense compensation and State and local noneducation compensation. A single intermediate input cost index is used for business and government for 1972-96; it is based primarily on detailed PPI's. These own-account software price estimates are based on the assumption that the productivity of computer programmers and systems analysts does not change; thus, increases in their compensation rates pass directly into higher prices. This assumption is the same as that made elsewhere in the NIPA's when prices are based on costs.

Beginning with 1997, a fixed-weighted index (1996 weights) of compensation rates and intermediate input costs is used. In the next annual NIPA revision, a chain-weighted index will be incorporated for 1997. The intermediate input costs index is calculated as it is in earlier years. The business sector compensation rates are based on the BLS employment cost index for total compensation in private industry. The government price indexes for Federal nondefense compensation and State and local noneducation compensation continue to be used to estimate the government price index.

Prior to 1972, a fixed-weighted index (1972 weights) of compensation rates and of intermediate inputs is used. Source data to calculate weights are not available for these years. For the business sector, the compensation rates are extrapolated back using the NIPA estimates of wages and salaries per full-time equivalent employee in the business services industry. The government sector uses the indexes for Federal nondefense compensation and State and local noneducation compensation.

Custom software.--Custom software consists of a mixture of new programming and existing programs or program modules, including prepackaged software, that are incorporated into new systems. Therefore, the price index for custom software is constructed as a weighted average of the percentage changes in the price indexes for business own-account software and for prepackaged software. The weights, which are selected arbitrarily, are 75 percent for changes in business own-account software prices and 25 percent for changes in prepackaged software prices.

CFC and business incomes

The CFC estimates for all software recognized as investment are derived from BEA's capital stock estimates. These estimates are prepared using the perpetual-inventory method, which is based on the estimates of software investment described earlier and the same depreciation patterns used for most types of capital goods.²² In determining the depreciation pattern, a 3-year service life is used for prepackaged software, and a 5-year service life is used for both custom software and own-account software; the 3-year service life is the same as that used in current tax law. (These service lives roughly correspond to annual geometric depreciation rates

²² For detailed information on the capital stock estimates, see Arnold J. Katz and Shelby W. Herman, "Improved Estimates of Fixed Reproducible Tangible Wealth, 1925-95," *Survey* 77 (May 1997): 69-92, and U.S. Department of Commerce, Bureau of Economic Analysis. *Fixed Reproducible Tangible Wealth in the United States, 1929-94*. Washington, D.C.: U.S. Government Printing Office, August 1999. M3-M33.

of 55 percent and 33 percent.) The service lives are based on some indirect quantitative estimates of the relationships between computers expenditures and software expenditures, anecdotal evidence (including an informal survey of business use of software previously conducted by BEA) about how long software is used before it is replaced, and tax-law-based lives of software.

Separate estimates of CFC are prepared for software expenditures by private businesses, nonprofit institutions serving individuals, general government agencies (both Federal and State and local governments), and by government enterprises, both Federal and State and local governments using the investment estimates. For private businesses, both corporations and sole proprietorships and partnerships, as well as for the nonprofit institutions, estimates of CFC by industry are prepared using investment in software data from BEA's capital stock estimates, which are available by industry and by legal form of organization. Own-account software production by industry and by legal form of organization is also based on the NIPA investment estimates and capital stock estimates.

B. Quarterly estimates

Like most of the components of GDP, the annual estimates of software are based on source data that are more comprehensive and reliable than those available for the quarterly estimates.²³ The quarterly estimates are prepared by interpolating and extrapolating the annual levels, using as indicators source data whose changes are similar to the changes in the annual estimates and--when such indicator series are not available--using mathematical techniques that generate smooth quarterly changes or using judgmental trends.

Current-dollar investment estimates

Table 9 summarizes the source data used as indicators for calculating the quarterly estimates of current-dollar software investment.

Purchased software.--The source data used for prepackaged and custom software are essentially identical. For 1959-75, quarterly estimates for both types of software were prepared using interpolation without an indicator series. For 1976-87, the indicator series for both types of software was unemployment insurance (UI) wage and salary data for SIC 7372 (computer programming services and prepackaged software). For 1988-98, the indicator series for custom and for prepackaged software were UI data for SIC 7371 (computer programming services) and SIC 7372 (prepackaged software), respectively.²⁴ For 1999, these UI series were used to extrapolate the quarterly estimates; until the UI series become available, a judgmental trend is used. (UI wage and salary data are available with a two-quarter lag for the advance and the

²³ See Moulton, Parker, and Seskin, "Definitional and Classificational Changes," Survey 17-20.

²⁴ Beginning with 1988, the UI wage and salary data reflected a change introduced in the 1987 SIC that created separate industries for custom and prepackaged software.

preliminary current-quarterly estimates and with a one-quarter lag for the final current-quarterly estimates.)

Own-account software.--Beginning with 1959, a lagged three-quarter moving average of private fixed investment in computers and peripheral equipment was used as the indicator series for business software and for State and local government software. A lagged three-quarter moving average of Federal Government investment in computers and peripheral equipment was used as the indicator series for Federal Government software.

Price estimates

Table 10 summarizes the source data used as indicators for calculating the quarterly estimates of software prices. Real quarterly software investment at the most detailed level was derived by deflation--that is, by dividing the current-dollar quarterly investment flows by price indexes.²⁵

Prepackaged software.--For 1959-96, this price index was prepared by interpolation without an indicator series. For 1997, the indicator series was a quarterly version of BEA's matched-model price index for prepackaged software, which was linked to the producer price index (PPI) for "prepackaged software--applications software" (PPI 73722) that BLS began publishing in December 1997; this PPI was used as the indicator series thereafter.

Custom software.--Beginning with 1959, this price index was prepared using as the indicator series a weighted average (25 percent prepackaged software and 75 percent business own-account software) of the percent changes in the price indexes for prepackaged software and for business own-account software (described next).

Business own-account software.--This price index was prepared using as the indicator series a weighted average of price indexes for intermediate inputs, for compensation of computer programmers, and for compensation of computer systems analysts. For all quarters, the intermediate inputs price index was based primarily on detailed PPI estimates. For 1959-79, the price indexes for compensation of computer programmers and of systems analysts were estimated without an indicator series. Beginning with 1980, the employment cost index for "total compensation, all workers, private industry" was used as the indicator series. The compensation price indexes and the intermediate inputs price index were combined using a Fisher chain-type formula to calculate the indicator series for the business own-account software price index.

Government own-account software.--Separate price indexes for Federal Government and for State and local government own-account software were calculated using the same methodology as that used for business, but using different compensation price indexes. For

²⁵ Aggregate measures of software, such as "all business" or "all government" were calculated using the Fisher index-number formula.

Federal Government own-account software, an adjusted NIPA price index for Federal nondefense compensation was used to estimate the programmer and systems analyst price indexes.²⁶ For State and local government own-account software, the NIPA price index for compensation of State and local government noneducation employees was used.

Consumption of fixed capital (CFC) and business incomes

Quarterly estimates of CFC for each software category were calculated as the product of quarterly estimates of real CFC--derived by interpolating annual estimates without an indicator series--and quarterly software price indexes. Estimates for the current quarters were prepared as the product of judgmental projections of real CFC and the current-quarterly software prices described earlier. Real CFC was calculated separately for total investment, for business and government investment, and within government, for Federal Government defense and nondefense and for State and local government. In addition, separate estimates were prepared for Federal Government enterprises, for State and local government enterprises, and for nonprofit institutions serving individuals. For capital consumption allowances and the other adjustments to business incomes, separate estimates were not prepared; the CFC's for these components were assumed to change quarterly in a manner similar to the components of which they are a part.

Real GDP

Real quarterly software investment, at the most detailed level, is derived by deflation, or dividing the current-dollar quarterly investment flows by price indexes.²⁷ Real software investment is calculated separately for business and government investment, and within business and government investment for each of the three types of software. In addition, separate estimates are made for 5 categories of Federal and State and local government software investment. In total, there are 18 detailed levels of investment. Quarterly estimates of general government CFC and CFC of nonprofit institutions serving individuals were described in the previous paragraph.

Table 11 shows, for selected years, software investment by type and by sector, and price indexes for software by type. Table 12 shows, for all years, prices for software, by type and by sector; prepackaged and custom software prices are the same for all sectors. Table 13 shows, for all years, yearend net stocks of private fixed assets, including software.

²⁶ The adjustment changes the NIPA treatment of pay raises by distributing the amount throughout the entire year; in the published compensation series, pay raises are usually allocated to the first quarter. This adjustment eliminates the volatility in the own-account investment series that would have appeared in the real own-account software investment series.

²⁷ Aggregate measures of software, such as "all business" or "all government" software are calculated using the Fisher index-number formula.

Table 1.—GDP and Final Sales of Software

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
	Billions of chained (1996) dollars; SAAR											
GDP	6,113.3	6,368.4	6,591.8	6,707.9	6,676.4	6,880.0	7,062.6	7,347.7	7,543.8	7,813.2	8,144.8	8,495.7
GDP less final sales of software	6,089.3	6,336.6	6,547.4	6,653.3	6,612.0	6,804.5	6,974.4	7,247.9	7,432.0	7,682.1	7,993.0	8,317.7
Final sales of software, total /1/	37.7	43.8	53.5	61.4	68.9	78.6	89.9	100.8	112.2	131.1	152.2	180.0
Personal consumption expenditures	0.2	0.3	0.4	0.5	0.8	1.1	1.7	2.4	3.6	5.8	9.4	13.2
Private fixed investment	27.9	32.4	40.1	45.9	51.4	58.7	66.8	74.3	82.0	95.1	109.4	129.2
Exports /2/	0.4	0.5	0.6	1.2	1.5	2.0	2.5	3.1	3.2	2.8	3.3	3.4
Less: Imports /2/	0.1	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.5	0.7	0.7
Government /3/	11.1	12.5	14.8	16.2	17.1	18.7	20.4	22.3	24.3	27.9	31.2	36.1
Residual: GDP less final sales of software /4/	-15.5	-13.8	-11.4	-9.0	-6.2	-4.7	-2.8	-1.8	-0.7	0.0	-0.8	-3.2
	Percent change from preceding period at annual rates											
GDP	3.4	4.2	3.5	1.8	-0.5	3.0	2.7	4.0	2.7	3.6	4.2	4.3
GDP less final sales of software	3.3	4.1	3.3	1.6	-0.6	2.9	2.5	3.9	2.5	3.4	4.0	4.1
Difference	0.1	0.1	0.2	0.2	0.1	0.1	0.2	0.1	0.2	0.2	0.2	0.2
Final sales of software, total /1/	12.3	16.1	22.2	14.7	12.2	14.0	14.4	12.1	11.3	16.8	16.1	18.2
	Billions of dollars; SAAR											
Final sales of software, total /1/	43.7	51.2	61.3	69.3	78.0	83.7	95.3	104.5	115.8	131.1	146.5	168.8
Personal consumption expenditures	1.2	1.7	1.8	2.0	2.8	3.0	3.6	4.4	5.2	5.8	6.4	7.5
Private fixed investment	31.4	36.7	44.4	50.2	56.6	60.8	69.4	75.5	83.5	95.1	106.6	123.4
Exports /2/	0.4	0.5	0.6	1.2	1.5	2.0	2.5	3.1	3.2	2.8	3.3	3.2
Less: Imports /2/	0.1	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.5	0.6	0.6
Government /3/	10.9	12.5	14.7	16.1	17.4	18.3	20.2	22.0	24.5	27.9	30.8	35.2

1. Software estimates include own-account production and exclude software embedded in equipment.
2. Includes software classified as goods and excludes software classified as services.
3. Excludes services of software, measured by consumption of fixed capital, for general government.
4. Equals the difference between directly calculated chained (1996) dollar GDP less final sales of software and GDP less the sum of the individual components of final sales of software shown above.

Table 2.–Changes in GDP and GDI Components Resulting From Recognition of Software as Investment

Components	Change due to:
Gross domestic product	
Personal consumption expenditures	
Nonprofit institutions	Software purchases reclassified from consumption to investment and consumption of fixed capital (CFC) added
Other	No change; software previously included
Gross private domestic investment:	
Equipment and software	Non-embedded software reclassified from intermediate consumption to investment
Change in private inventories	No change; software previously included
Net exports of goods and services	No change; software previously included
Government consumption expenditures and gross investment:	
Investment	
General government	Software reclassified from consumption to investment
Government enterprises	Software reclassified from deduction from current surplus to investment
Consumption expenditures:	
Consumption of fixed capital	General government CFC added
Other expenditures	Software of general government reclassified from consumption to investment
Gross domestic income	
Consumption of fixed capital:	
Private	CFC for business and CFC for nonprofit institutions serving individuals are added
Capital consumption allowance (CCA)	CFC valued at historical cost
Less: Capital consumption adjustment (CCAdj)	CCA less CFC
Government	
General government	CFC added
Government enterprises	CFC added
Current surplus of government enterprises	Purchased software reclassified from intermediate consumption to investment, own-account production added as a receipt, and CFC added as a deduction
Corporate profits before tax and proprietors' income	Purchased software reclassified from intermediate consumption to investment, own-account production added as a receipt, and CFC added as a deduction
CCAdj (corporate profits and proprietors' income)	CCA less CFC

Table 3.--Primary Source Data for Prepackaged and Custom Software Investment

	1960-76	1977-84	1985-86	1987	1988	1989	1990-91	1992	1993-98
Receipts	A		B	C	B			C	B
Intermediate consumption	D							C	D
Exports and imports	E					F			
Inventories	G			C	G			C	G
Prepackaged PCE	G	H							
Custom PCE	G								
Government share	I			C	J			C	K

Sources:

- A Computer Business Equipment Manufacturers' Association estimates of software products and software professional services (1961-64 and 1966-69 are interpolations at constant rates of growth)
- B Census Bureau, Service Annual Survey
- C BEA input-output accounts
- D 1992 ratio of intermediate consumption to receipts held constant
- E Trend projections backwards from 1989 estimate
- F BEA international transactions accounts
- G Zero values assumed
- H NIPA's
- I 1987 share held constant
- J Shares interpolated linearly between 1987 and 1992 values
- K 1992 share held constant

**Table 4.-- Principal Source Data and Estimating Methods Used in Preparing Estimates
of Annual Current-Dollar Prepackaged and Custom Software Investment**

Component	1992 Value (billions of dollars)	Benchmark-year estimates	Other years
Total shipments of domestic producers Prepackaged Custom	48.7 22.6 26.1	Census Bureau's quinquennial census of services industries and census of manufacturers.	Receipts of prepackaged and custom programming industries from the Census Bureau's service annual survey.
Less: Intermediate purchases Prepackaged Custom	0.3 0.3 0.0	Detail from the input-output estimates for computer manufacturing industry from census of manufacturers.	Ratio of intermediate purchases to total receipts in benchmark year times total receipts.
Less: Inventory change Prepackaged Custom	0.0 -0.0 0.0	Detail from the input-output estimates.	Assumed to be zero (lack of source data).
Equals: Domestic supply to final uses Prepackaged Custom	48.4 22.3 26.1	Calculated as a residual.	Calculated as a residual.
Less: Exports Prepackaged Custom	2.0 1.3 0.7	Balance of payments amounts: Exports documents compiled monthly by the Census Bureau.	Balance of payments amounts: Exports and imports documents compiled monthly by the Census Bureau.
Plus: Imports Prepackaged Custom	0.4 0.2 0.2	Balance of payments amounts: Imports documents compiled monthly by the Census Bureau, with adjustments by BEA for valuation (1995 forward).	Balance of payments amounts: Exports and imports documents compiled monthly by the Census Bureau, with adjustments by BEA for valuation.
Equals: Supply to domestic final uses Prepackaged Custom	46.7 21.2 25.5	Calculated as a residual.	Calculated as a residual.

Less: Personal consumption expenditures Prepackaged Custom	2.3 2.3 0.0	Detail from the input-output estimates.	Retail-control method, using retail sales from the Census Bureau's Annual Survey of Retail Trade.
Equals: Supply to domestic fixed investment Prepackaged Custom	44.4 18.9 25.5	Calculated as a residual.	Calculated as a residual.
Business investment Prepackaged Custom	33.4 16.6 16.8	Detail from the input-output estimates.	Ratios of business to total software fixed investment of each type in benchmark year held constant.
Government investment Prepackaged Custom	11.0 2.3 8.7	Detail from the input-output estimates.	Ratios of government to total software fixed investment of each type in benchmark year held constant.
General government Prepackaged Custom	10.7 2.2 8.5	Detail from the input-output estimates.	Ratios of general government to total software fixed investment of each type in benchmark year held constant.
Federal Prepackaged Custom	7.9 1.0 6.9	Detail from the input-output estimates.	Ratios of Federal government to total software fixed investment of each type in benchmark year held constant.
State and local Prepackaged Custom	2.8 1.2 1.6	Detail from the input-output estimates.	Ratios of State and local government to total software fixed investment of each type in benchmark year held constant.
Government enterprises Prepackaged Custom	1.4 1.2 0.2	Detail from the input-output estimates.	Ratios of government enterprises to total software fixed investment of each type in benchmark year held constant.

Table 5.--Primary Source Data and Methods for Calculating Own-Account Software Investment

	1959-71	1972-84	1985-86	1987	1988-91	1992	1993-96	1997-98
Numbers of employees/1/		A	B					
Wages per employee		C		D				
Compensation per employee		E	F					
Operating expenses		G		H	I	H	J	
Own account software		K	L					

1. Computer programmers and computer systems analysts

Sources and methods:

- A Computer Business Equipment Manufacturers' Association; 1985 ratio of government to business held constant
- B BLS National Industry-Occupation Employment Matrix (unpublished), separate estimates for 9 industries, Federal and State and local governments; separate estimates for computer programmers and computer systems analysts
- C Extrapolated back from 1987 using NIPA estimates of compensation per full time equivalent employee in the business services industry
- D BLS estimates of median usual weekly earnings per full time wage and salary workers, based on data collected in the current population survey; separate estimates for computer programmers and computer systems analysts
- E NIPA 1985 ratio of compensation to wages and salaries held constant (business), and price indexes for nondefense compensation (Federal government) and noneducation compensation (State and local governments) used to extrapolate compensation rates linked to the national median in 1985
- F NIPA estimates of compensation versus wages and salaries; separate estimates for 9 private industries, Federal and State and local governments
- G 1987 ratio of operating expenses to compensation held constant
- H Ratio of operating expenses to compensation, based on data from the Census of Service Industries, 1987 and 1992
- I Ratios interpolated linearly between 1987 and 1992 values
- J 1992 ratio of operating expenses to compensation held constant
- K The sum of business and government own-account software extrapolated back using business purchases of computers and peripheral equipment and the ratio of business and government own-account software (1972-81) to these purchases. Government expenditures extrapolated back separately using the ratio of government own-account software (1972) to these purchases; business expenditures derived as a residual.
- L Share of operating expenses allocated to software investment held constant at 50 percent; share based on a private study
- M Business own-account software extrapolated using business purchases of computers and peripheral equipment; government own-account software extrapolated using Federal government purchases of computers and peripheral equipment.

Table 6.--Prepackaged Software Price Estimates: Underlying Source Data and Estimating Methodologies

1959-84	1985-93	1994-97	1998
A	B, C	D	E

Source data:

- A BEA price index for computers and peripherals in private fixed investment
- B BEA hedonic price index for spreadsheets and word processors
- C Oliner and Sichel's matched model price index for data bases, spreadsheets, and word processors
- D BEA matched-model price index for selected types of prepackaged software
- E Producer price index for applications software

Methodologies: All calculations and weightings done in percent changes from preceding years.

- 1959-84: Series A times 0.6
- 1985-93: Series B times 0.5 plus series C times 0.5
- 1994-97: Series D less a bias adjustment of 3.15 percent
- 1998: Series E less a bias adjustment of 3.15 percent

Table 7.--Prepackaged Software Price Indexes
(Percent change)

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Hedonic	-15.0	-9.6	-21.2	-31.3	-22.7	-10.2	-31.9	-7.5	–	–	–	–	–
Matched-model	-10.7	-2.3	-0.9	-2.1	-2.9	0.4	-7.8	-2.0	-5.4	-2.2	-2.5	-5.2	-5.0
Prepackaged	-12.8	-6.0	-11.0	-16.7	-12.8	-4.9	-19.8	-4.7	-8.6	-5.4	-5.7	-8.4	-8.1
Addendum: Computers/1/	-13.9	-14.8	-7.1	-6.6	-9.3	-10.2	-14.5	-14.7	-11.8	-16.5	-23.8	-22.5	-26.0

1. BEA price index for computers and peripherals in private fixed investment

Table 8.--Methodologies for Estimating Own-Account Software Price Indexes

	1959-71	1972-86/1/	1987-96/1/	1997-98
Compensation:				
Business:				
Programmers	D	A/2/	A/3/	F
Systems analysts	D	A/2/	A/3/	F
Government:				
Federal:				
Programmers	E	E	E	E
Systems analysts	E	E	E	E
State and local:				
Programmers	E	E	E	E
Systems analysts	E	E	E	E
Intermediate inputs:				
Business	B	B	B	B
Government	B	B	B	B
Own account investment:				
Business	C	C	C	C
Government	C	C	C	C

Methodologies:

- A Derived from compensation per employee (BLS and NIPA data):
[Employment*(Compensation/Wages)*National Median Wage Rates]/Employment
- B Weighted average of PPI's and BEA price indexes for materials, electricity, communications, rent, depreciation, and overhead employee compensation
- C Weighted sum of compensation indexes for programmers and computer systems analysts, intermediate inputs costs index
- D Extrapolated by NIPA wages and salaries per full-time equivalent employee in the business services industry
- E Price indexes for nondefense compensation (Federal government) and noneducation compensation (State and local governments)
- F Extrapolated using BLS' Employment Cost Index for total compensation in private industry

-
- 1. Estimated forward from 1987, and extrapolated back from 1987
 - 2. Total private aggregates--no industry detail
 - 3. Aggregated from nine industries

Table 9.--Indicator Series for Quarterly Estimates of Current-Dollar Software Investment

Software type	1959-75	1976-87	1988-98	1999
Prepackaged	A	B	C	C/1/
Custom	A	B	D	D/1/
Business own-account	E			
Federal own-account	F			
State and local own-account	E			

Source or indicator:

- A Interpolated without an indicator series
- B Wages in SIC 7372 (1977); eight-quarter moving average lag (BLS: Wages of workers covered by State unemployment insurance)
- C Wages in SIC 7372 (1987); eight-quarter moving average lag (BLS: Wages of workers covered by State unemployment insurance)
- D Wages in SIC 7371 (1987); eight-quarter moving average lag (BLS: Wages of workers covered by State unemployment insurance)
- E NIPA current-dollar private fixed investment, computers and peripheral equipment; three-quarter moving average lag
- F NIPA current-dollar Federal Government gross investment, computers and peripheral equipment; three-quarter moving average lag

1. Current-quarterly values for wages are projected based on previous quarters' wages.

Table 10.--Indicator Series for Quarterly Estimates of Software Prices

Software type	1959-79	1980-96	1997	1998-99
Prepackaged	A		B	C
Custom	D, E			
Business own-account	F, G	G, H		
Federal own-account	G, I			
State and local own-account	G, J			

Source or indicator:

- A Interpolated without an indicator series
- B BEA monthly matched-model index
- C Producer price index 73722 (all prepackaged applications software)
- D Prepackaged software index
- E Business own-account software index
- F Compensation rates interpolated without an indicator series
- G BEA own-account software intermediate inputs index
- H BLS employee compensation index, all workers, private industry
- I Federal Government nondefense compensation price index
- J State and local government noneducation compensation price index

Table 11.—Software Investment and Prices

	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
Current dollars, billions										
Total:	0.0	0.2	0.2	0.3	0.5	0.7	0.8	1.3	1.5	1.7
Prepackaged	—	—	—	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Custom	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.4
Own account	0.0	0.1	0.2	0.2	0.5	0.6	0.8	1.1	1.2	1.3
Business (private):	0.0	0.1	0.2	0.2	0.4	0.5	0.7	1.0	1.2	1.3
Prepackaged	—	—	—	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Custom	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2
Own account	0.0	0.1	0.1	0.2	0.4	0.5	0.6	0.9	1.0	1.0
Federal government:	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.3
Prepackaged	—	—	—	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Custom	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Own account	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
State and local governments:	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
Prepackaged	—	—	—	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Custom	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Own account	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
Price indexes, 1996 = 100										
Prepackaged/1/	7,636.6	5,601.2	4,793.5	3,829.2	3,151.7	3,051.9	2,634.5	2,165.0	1,938.3	1,778.2
Custom	84.2	79.8	78.4	75.5	72.9	73.5	71.8	69.7	69.0	69.4
Business own account	21.4	21.8	22.3	22.7	23.0	23.5	23.8	24.3	24.9	25.7
Federal government own account	16.8	17.1	17.7	18.0	18.4	19.0	19.4	20.0	20.4	21.4
State and local governments own account	17.3	17.7	18.1	18.5	18.8	18.9	19.3	20.0	20.9	21.9
Chained (1996) dollars, billions										
Business (private):										
Prepackaged	—	—	—	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Custom	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.3
Own account	0.1	0.5	0.6	0.8	1.7	2.1	2.6	3.7	4.0	4.0
Federal government:										
Prepackaged	—	—	—	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Custom	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2
Own account	0.0	0.1	0.1	0.1	0.3	0.4	0.4	0.6	0.7	0.7
State and local governments:										
Prepackaged	—	—	—	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Custom	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Own account	0.0	0.1	0.1	0.1	0.2	0.2	0.3	0.4	0.4	0.4

1. Prepackaged software prices for 1959-61 used only in the calculation of custom software prices.

Table 11, continued.—Software Investment and Prices

	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
Current dollars, billions										
Total:	2.3	3.1	3.2	3.7	4.4	5.4	6.6	7.2	7.6	9.1
Prepackaged	0.1	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.8
Custom	0.6	1.1	1.3	1.5	1.9	2.4	2.9	3.0	3.3	3.8
Own account	1.6	1.8	1.7	1.9	2.1	2.5	3.2	3.6	3.7	4.6
Business (private):	1.8	2.3	2.4	2.8	3.2	3.9	4.8	5.2	5.5	6.6
Prepackaged	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.7
Custom	0.4	0.7	0.8	0.9	1.2	1.5	1.8	1.9	2.1	2.4
Own account	1.3	1.4	1.4	1.6	1.7	2.0	2.5	2.8	2.9	3.6
Federal government:	0.4	0.6	0.6	0.7	0.9	1.2	1.4	1.6	1.7	2.0
Prepackaged	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Custom	0.2	0.4	0.4	0.5	0.6	0.8	1.0	1.0	1.1	1.3
Own account	0.2	0.2	0.2	0.2	0.3	0.3	0.4	0.5	0.5	0.7
State and local governments:	0.1	0.2	0.2	0.2	0.2	0.3	0.4	0.4	0.4	0.5
Prepackaged	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Custom	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
Own account	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.4
Price indexes, 1996 = 100										
Prepackaged	1,664.6	1,572.0	1,342.6	1,181.9	1,146.4	1,023.3	976.8	879.7	810.1	651.7
Custom	70.3	71.8	71.1	70.7	72.4	76.5	80.4	81.5	83.0	83.0
Business own account	26.7	28.0	29.0	29.9	31.2	34.6	37.5	39.4	41.4	44.1
Federal government own account	22.2	24.2	26.0	27.4	29.2	32.4	35.7	37.7	40.7	42.8
State and local governments own account	22.9	24.2	25.6	27.0	28.9	32.2	35.2	37.5	40.0	42.8
Chained (1996) dollars, billions										
Business (private):										
Prepackaged	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
Custom	0.6	0.9	1.1	1.3	1.6	2.0	2.3	2.3	2.5	2.9
Own account	4.9	5.2	4.7	5.3	5.5	5.8	6.7	7.2	7.0	8.0
Federal government:										
Prepackaged	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Custom	0.3	0.5	0.6	0.7	0.9	1.1	1.2	1.2	1.3	1.5
Own account	0.8	0.8	0.7	0.8	0.9	1.0	1.2	1.3	1.3	1.5
State and local governments:										
Prepackaged	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Custom	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
Own account	0.5	0.5	0.5	0.5	0.6	0.6	0.7	0.8	0.7	0.9

Table 11, continued.—Software Investment and Prices

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Current dollars, billions										
Total:	11.8	14.6	17.7	20.9	24.4	29.7	34.6	37.5	42.2	49.2
Prepackaged	1.0	1.4	1.9	2.2	3.1	4.6	5.6	6.1	6.7	8.7
Custom	4.6	5.7	7.2	7.8	9.1	10.7	12.2	13.7	15.1	18.0
Own account	6.2	7.5	8.6	10.8	12.2	14.5	16.7	17.8	20.3	22.4
Business (private):	8.7	10.7	12.9	15.4	18.0	22.1	25.6	27.8	31.4	36.7
Prepackaged	0.9	1.2	1.6	1.9	2.6	4.0	4.9	5.3	5.9	7.6
Custom	2.9	3.6	4.6	4.9	5.7	6.7	7.7	8.6	9.5	11.4
Own account	4.9	5.9	6.7	8.5	9.6	11.4	13.1	13.9	16.0	17.7
Federal government:	2.5	3.1	3.8	4.2	5.0	5.9	6.9	7.5	8.4	9.5
Prepackaged	0.1	0.1	0.2	0.2	0.2	0.4	0.5	0.5	0.5	0.7
Custom	1.6	1.9	2.4	2.6	3.1	3.6	4.1	4.6	5.1	5.8
Own account	0.8	1.0	1.2	1.4	1.6	1.9	2.3	2.4	2.8	3.0
State and local governments:	0.7	0.8	1.0	1.2	1.4	1.8	2.1	2.2	2.4	2.9
Prepackaged	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.5
Custom	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.7
Own account	0.5	0.6	0.7	0.8	1.0	1.2	1.4	1.5	1.6	1.7
Price indexes, 1996 = 100										
Prepackaged	584.4	507.3	470.0	439.8	395.6	350.0	318.0	277.3	260.8	232.0
Custom	86.8	90.9	95.8	99.8	100.5	101.1	101.3	100.2	100.9	102.6
Business own account	48.4	53.5	58.7	63.2	65.9	69.0	71.2	73.2	75.4	79.9
Federal government own account	46.3	51.0	55.9	59.5	61.5	64.6	66.4	68.0	69.9	73.4
State and local governments own account	46.2	50.7	55.5	59.3	63.3	66.8	69.6	71.9	74.0	77.6
Chained (1996) dollars, billions										
Business (private):										
Prepackaged	0.2	0.2	0.3	0.4	0.7	1.1	1.5	1.9	2.2	3.3
Custom	3.4	4.0	4.8	4.9	5.7	6.6	7.6	8.6	9.4	11.2
Own account	10.0	10.9	11.5	13.5	14.6	16.5	18.3	19.0	21.2	22.1
Federal government:										
Prepackaged	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.3
Custom	1.8	2.1	2.5	2.6	3.0	3.5	4.1	4.6	5.0	5.7
Own account	1.8	2.0	2.1	2.4	2.7	3.0	3.5	3.6	3.9	4.1
State and local governments:										
Prepackaged	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.2
Custom	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.5	0.5	0.7
Own account	1.1	1.1	1.2	1.4	1.5	1.8	2.0	2.0	2.1	2.3

Table 11, continued.—Software Investment and Prices

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Current dollars, billions										
Total:	59.1	66.3	74.0	79.2	89.8	97.6	108.0	123.0	137.4	158.9
Prepackaged	12.0	15.3	16.3	18.9	22.3	25.3	29.3	35.4	38.6	40.7
Custom	20.2	21.9	24.0	25.5	27.8	31.6	35.7	43.2	51.4	64.1
Own account	26.9	29.1	33.7	34.7	39.6	40.8	43.0	44.4	47.4	54.2
Business (private):	44.4	50.2	56.6	60.8	69.4	75.5	83.5	95.1	106.6	123.4
Prepackaged	10.5	13.3	14.3	16.6	19.6	22.2	25.7	31.1	33.9	35.7
Custom	13.0	14.2	15.7	16.8	18.4	20.8	23.6	28.5	33.9	42.3
Own account	21.0	22.6	26.6	27.3	31.4	32.4	34.2	35.5	38.7	45.4
Federal government:	10.7	11.4	12.0	12.3	13.4	14.5	16.2	18.6	20.9	24.5
Prepackaged	0.8	1.0	1.0	1.0	1.2	1.4	1.6	1.9	2.1	2.2
Custom	6.3	6.5	6.9	7.0	7.6	8.6	9.8	11.8	14.1	17.5
Own account	3.5	3.8	4.2	4.3	4.6	4.5	4.8	4.8	4.7	4.8
State and local governments:	4.1	4.8	5.4	6.1	7.0	7.6	8.2	9.3	9.9	11.0
Prepackaged	0.7	0.9	1.0	1.3	1.5	1.7	2.0	2.4	2.6	2.7
Custom	0.9	1.2	1.4	1.7	1.8	2.1	2.4	2.9	3.4	4.2
Own account	2.4	2.7	2.9	3.1	3.6	3.8	3.9	4.0	3.9	4.0
Price indexes, 1996 = 100										
Prepackaged	193.3	168.5	160.3	128.5	122.4	112.0	106.0	100.0	91.6	84.2
Custom	101.7	101.8	103.1	99.5	100.6	99.5	100.9	100.0	99.0	98.5
Business own account	83.3	87.0	90.0	91.7	94.5	95.8	99.4	100.0	101.5	103.6
Federal government own account	76.8	79.3	83.6	85.4	89.1	92.2	98.0	100.0	102.0	103.4
State and local governments own account	80.9	84.4	87.5	89.8	92.0	94.6	99.0	100.0	101.7	103.4
Chained (1996) dollars, billions										
Business (private):										
Prepackaged	5.4	7.9	8.9	13.0	16.0	19.8	24.3	31.1	37.0	42.4
Custom	12.8	13.9	15.2	16.9	18.3	20.9	23.4	28.5	34.3	42.9
Own account	25.2	26.0	29.6	29.8	33.2	33.8	34.5	35.5	38.2	43.8
Federal government:										
Prepackaged	0.4	0.6	0.6	0.8	1.0	1.2	1.5	1.9	2.3	2.6
Custom	6.2	6.4	6.6	7.0	7.6	8.7	9.7	11.8	14.2	17.8
Own account	4.6	4.9	5.0	5.0	5.1	4.9	4.9	4.8	4.6	4.6
State and local governments:										
Prepackaged	0.4	0.5	0.6	1.0	1.2	1.5	1.8	2.4	2.8	3.2
Custom	0.9	1.1	1.4	1.7	1.8	2.1	2.3	2.9	3.4	4.3
Own account	3.0	3.2	3.4	3.5	3.9	4.0	3.9	4.0	3.9	3.9

Table 12.—Software Price Indexes

	Prepackaged	Custom	Business Own Account	Federal Government Own Account	State and Local Government Own Account
Year	1996 = 100				
1959	7,636.6	84.2	21.3	16.8	17.3
1960	5,601.2	79.8	21.8	17.1	17.7
1961	4,793.5	78.4	22.3	17.7	18.1
1962	3,829.2	75.5	22.7	17.9	18.5
1963	3,151.7	72.9	23.0	18.4	18.8
1964	3,051.9	73.5	23.5	19.0	18.9
1965	2,634.5	71.8	23.8	19.4	19.3
1966	2,165.0	69.7	24.3	20.0	20.0
1967	1,938.3	69.0	24.8	20.4	20.9
1968	1,778.2	69.3	25.7	21.4	21.9
1969	1,664.6	70.2	26.7	22.2	22.9
1970	1,572.0	71.8	28.0	24.2	24.2
1971	1,342.6	71.1	29.0	26.0	25.6
1972	1,181.9	70.7	29.9	27.3	27.0
1973	1,146.4	72.4	31.2	29.1	28.9
1974	1,023.3	76.5	34.6	32.4	32.2
1975	976.7	80.4	37.5	35.7	35.2
1976	879.7	81.5	39.4	37.7	37.5
1977	810.1	83.0	41.4	40.7	40.0
1978	651.7	83.0	44.1	42.8	42.8
1979	584.4	86.8	48.4	46.3	46.2
1980	507.3	90.9	53.5	51.0	50.7
1981	470.0	95.8	58.7	55.9	55.5
1982	439.8	99.8	63.2	59.5	59.3
1983	395.6	100.5	65.9	61.5	63.3
1984	350.0	101.1	69.0	64.6	66.8
1985	318.0	101.3	71.2	66.4	69.6
1986	277.3	100.2	73.2	68.0	71.9
1987	260.8	100.9	75.4	69.9	74.0
1988	232.0	102.6	79.9	73.4	77.6
1989	193.3	101.7	83.3	76.8	80.9
1990	168.5	101.8	87.0	79.3	84.4
1991	160.3	103.1	90.0	83.6	87.5
1992	128.5	99.5	91.7	85.4	89.8
1993	122.4	100.6	94.5	89.1	92.0
1994	112.0	99.5	95.8	92.2	94.6
1995	106.0	100.9	99.4	98.0	99.0
1996	100.0	100.0	100.0	100.0	100.0
1997	91.7	99.0	101.5	102.0	101.7
1998	84.2	98.5	103.6	103.4	103.4

Table 13.—Yearend Net Stock of Private Fixed Assets

Year	Current Cost			Real Cost	
	Billions of Dollars		Percent	Quantity Index (1996 = 100)	
	Total	Software	Ratio of Software to Total	Total	Software
1959	1,099.4	0.0	0.0	32.42	0.01
1960	1,131.4	0.1	0.0	33.41	0.12
1961	1,167.4	0.2	0.0	34.36	0.22
1962	1,209.0	0.3	0.0	35.47	0.33
1963	1,245.5	0.5	0.0	36.71	0.58
1964	1,330.3	0.7	0.1	38.13	0.83
1965	1,418.1	0.9	0.1	39.76	1.10
1966	1,538.7	1.3	0.1	41.42	1.54
1967	1,649.2	1.7	0.1	42.94	1.96
1968	1,815.7	2.1	0.1	44.58	2.34
1969	1,973.7	2.7	0.1	46.32	2.93
1970	2,129.6	3.5	0.2	47.88	3.70
1971	2,366.4	4.1	0.2	49.60	4.34
1972	2,613.5	5.1	0.2	51.64	5.24
1973	2,968.2	6.2	0.2	53.93	6.12
1974	3,489.4	7.9	0.2	55.81	7.05
1975	3,815.2	9.4	0.2	57.16	8.10
1976	4,207.5	10.7	0.3	58.76	9.01
1977	4,787.4	11.8	0.2	60.82	9.67
1978	5,473.0	13.7	0.3	63.24	10.75
1979	6,339.9	17.2	0.3	65.74	12.48
1980	7,212.7	21.2	0.3	67.73	14.40
1981	7,949.7	25.9	0.3	69.67	16.45
1982	8,376.1	30.5	0.4	71.10	18.67
1983	8,667.6	35.1	0.4	72.75	21.22
1984	9,163.5	41.5	0.5	75.07	24.65
1985	9,657.8	48.0	0.5	77.48	28.37
1986	10,266.6	53.9	0.5	79.79	31.81
1987	10,857.3	61.6	0.6	81.94	35.56
1988	11,540.9	70.6	0.6	84.09	40.07
1989	12,197.2	81.6	0.7	86.21	46.45
1990	12,760.3	94.7	0.7	88.14	52.82
1991	13,021.5	104.8	0.8	89.52	59.17
1992	13,582.6	115.4	0.8	90.99	66.15
1993	14,318.0	129.7	0.9	92.88	73.84
1994	15,203.7	142.9	0.9	94.99	81.69
1995	15,908.4	158.3	1.0	97.30	89.64
1996	16,722.5	173.7	1.0	100.00	100.00
1997	17,573.4	192.6	1.1	102.93	112.26
1998	18,642.9	220.4	1.2	106.35	128.48

Chart 1.--Current-Dollar Software

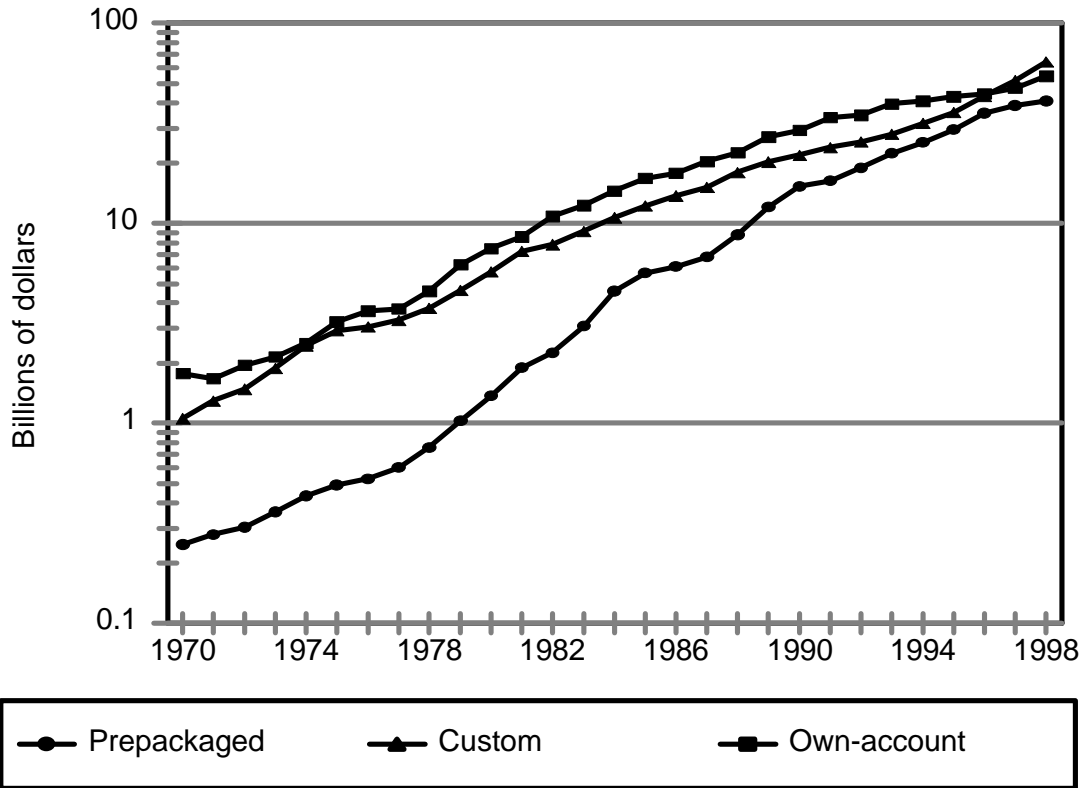


Chart 2.--Current-Dollar
Business Software

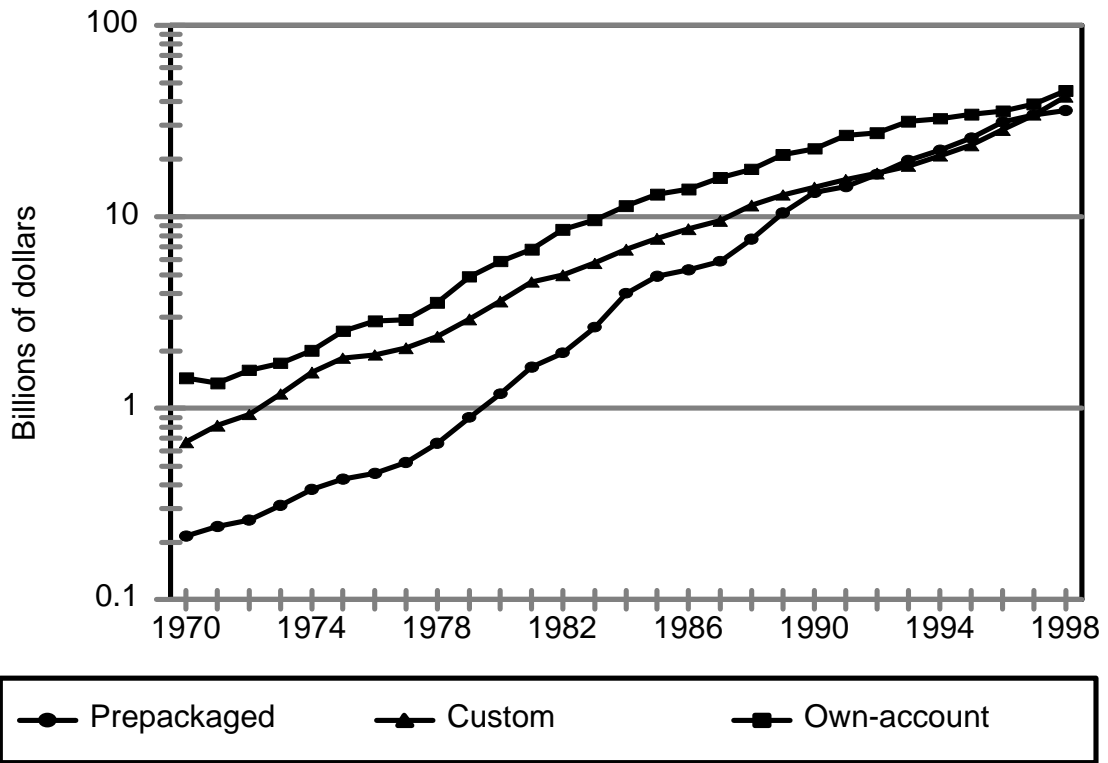


Chart 3.--Current-Dollar
Government Software

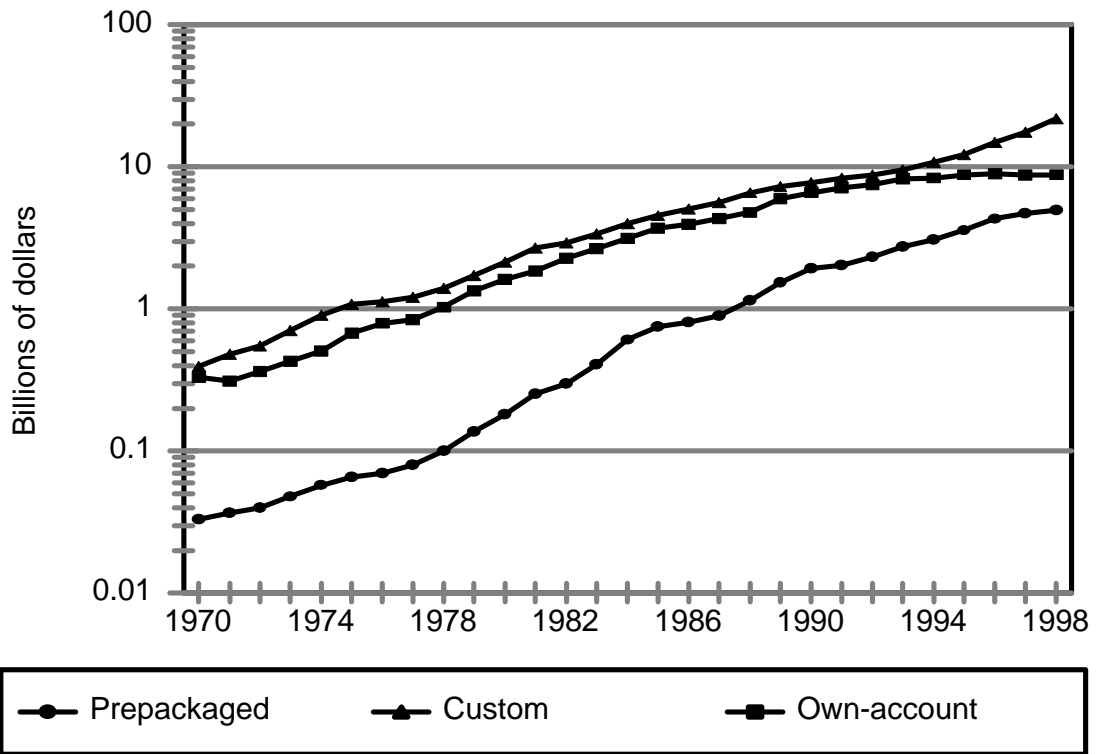
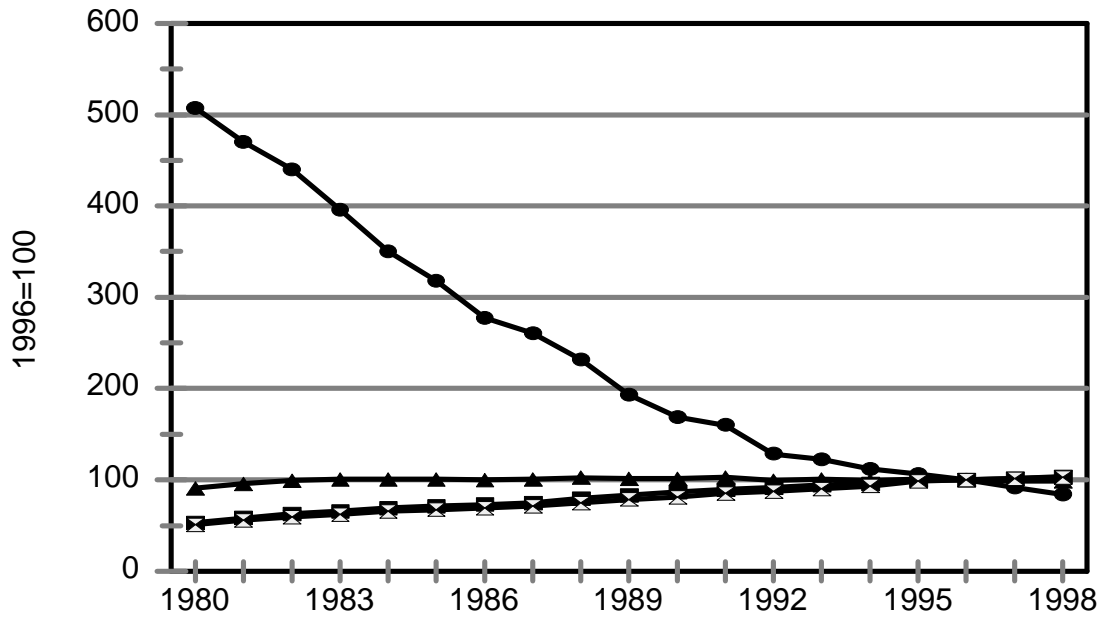


Chart 4.--Software Price Indexes



- Prepackaged
- ▲ Custom
- Business own-account
- ⊠ Government own-account

Chart 5.--Real Business Software Investment

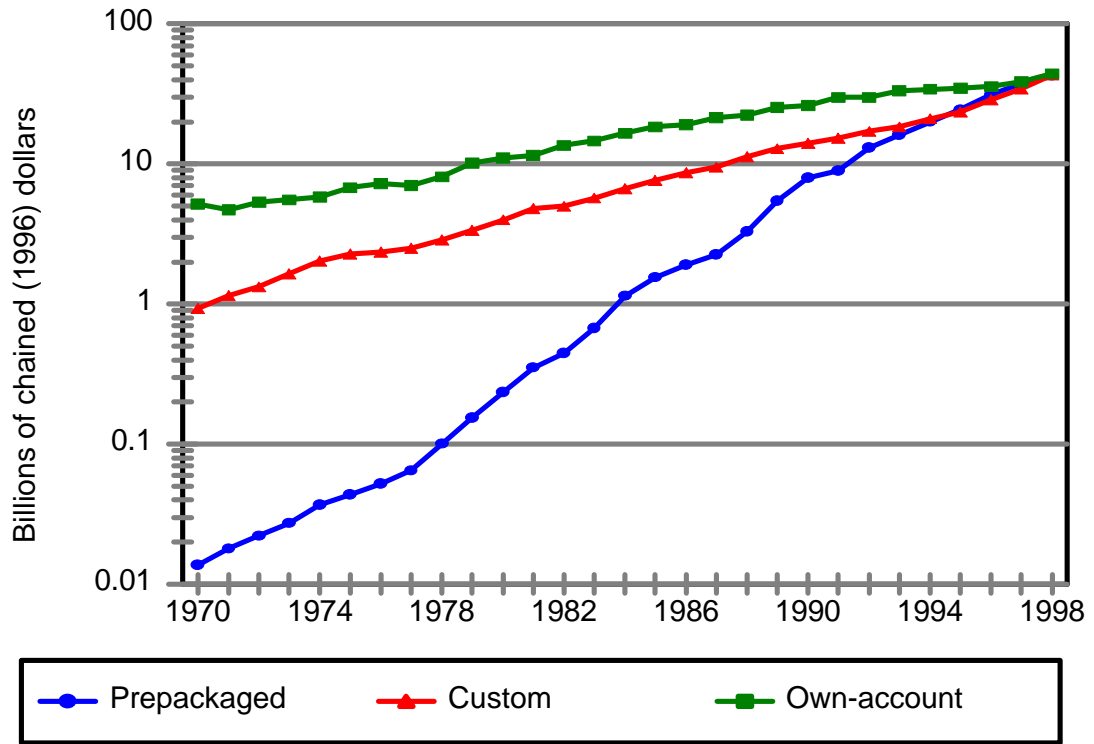


Chart 6.--Real Government Software Investment

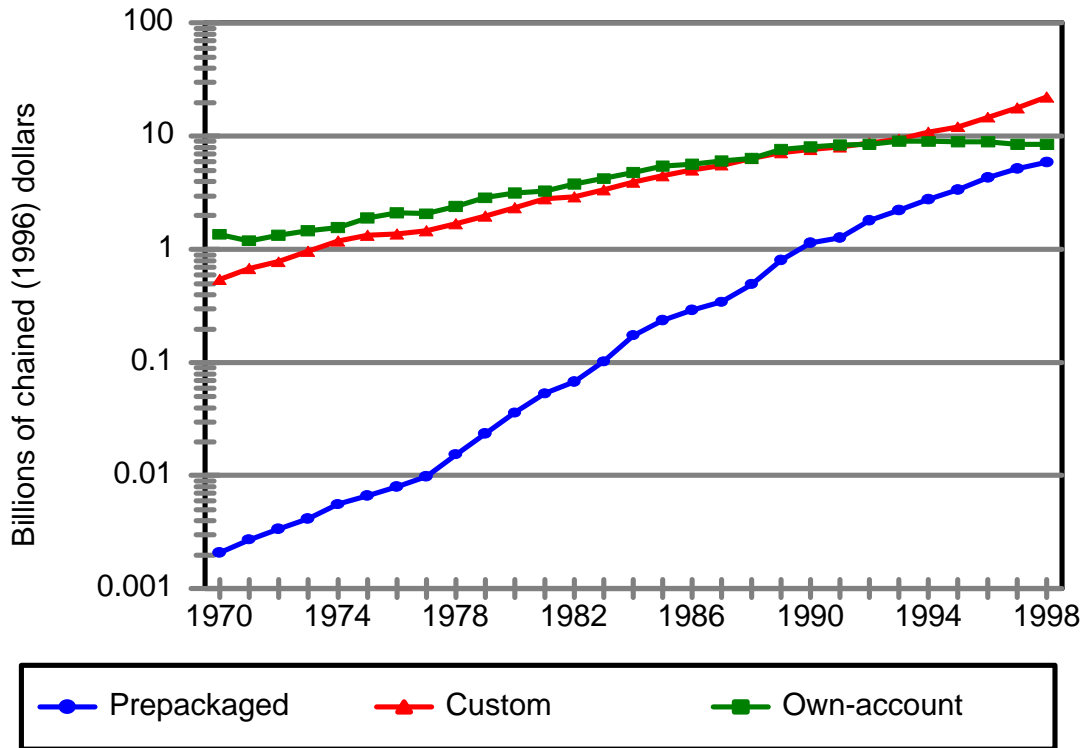


Chart 7.--Real GDP With and Without Final Sales of Software

