

Bureau of Labor Statistics
Multifactor Productivity
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Overview of Capital Inputs for the BLS Multifactor Productivity Measures

Since 1983, the Bureau of Labor Statistics (BLS) has published annual multifactor productivity (MFP) measures of the private business and private nonfarm business sectors. BLS has incorporated updated data and new and improved methodological estimation procedures into the multifactor productivity measures as they have become available. Starting with the release of the Bureau of Economic Analysis's (BEA) 2013 Comprehensive Revision of the National Income and Products Accounts (NIPA), updated measures have included a new major asset category known as "intellectual property products" and the introduction of two new residential assets. For the 1987-2015 period, intellectual property products have contributed more than a third of all capital intensity to the private nonfarm business sector¹. BLS uses fixed investment from BEA to calculate capital stocks that are then used for estimating capital inputs. Fixed investment are the expenditures used in the purchase of residential and non-residential structures, equipment, and intellectual property products. BEA defines fixed assets as assets derived as output from a production process that are used repeatedly—or continuously—in production processes for more than a year. Originally consisting of equipment and structures but excluding consumer durables (U.S. Department of Commerce, 2003), these fixed assets now include intellectual property products.

This document describes the procedures that BLS uses to estimate capital inputs and the impact of the 2013 Comprehensive Revision of the NIPA on the estimation of these capital inputs. BLS procedures for estimating capital inputs have always been closely tied to the BEA estimates of fixed assets. BLS has accordingly adjusted some of its procedures for estimating capital inputs to reflect the changes generated by the 2013 Comprehensive Revisions of the NIPA.

Procedures Used to Estimate Capital Input

An important focus of productivity measurement is determining the flow of capital services provided by a given stock of capital assets. The capital service flow is similar to the flow of labor hours but, unlike labor hours, usually cannot be measured directly because companies own most of the capital assets that they use. However, in the literature on productivity measurement, procedures have been developed to estimate the service flow from historical data on capital investments, estimates of the rates of deterioration and depreciation of capital, and income data of firms utilizing capital. The BLS methods, which closely follow models presented in the economic literature, are summarized here and described in more detail in BLS (U.S. Department of Labor, 1983).

BLS calculates measures of major sector capital in three basic steps. These are the estimation of detailed "productive capital stocks", the aggregation of productive stocks of various asset types within each industry to estimate industry capital inputs (capital service flows), and the aggregation of capital inputs across industries.

¹ See Table B in "Multifactor Productivity Trends – 2016."
http://www.bls.gov/news.release/archives/prod3_03302017.pdf

**Table 1. BEA and BLS Mean Asset Service Lives—NAICS-based
(revised August 20, 2013)**

Type of asset (BLS Asset Code) [NAICS]	Service Life (years)		Type of asset (BLS Asset Code)	Service Life (years)	
	BEA	BLS		BEA	BLS
Private nonresidential equipment					
Household furniture and fixtures (1)	12	15	Apparel and leather and allied products [315, 316].....	15	19
Other furniture (2).....	14	17	Paper products [322].....	16	20
Other fabricated metal products (3).....	18	22	Printing and related supported activities [323]	15	19
Steam engines and turbines (4).....	32	39	Petroleum and coal products [324]..	22	27
Internal combustion engines (5).....	8	10	Chemical products [325].....	16	20
Farm tractors (6).....	9	14	Plastic and rubber products [326] ..	14	17
Construction tractors (7).....	8	12	Nonmanufacturing industries	16	20
Agricultural machinery except tractors (8)..	14	17	General industrial equipment incl.		
Construction machinery except tractors (9)..	10	13	Handling (13):		
Mining and oil field machinery	11	13	Durable Manufacturing		
Metal working machinery (11):			Wood products [321].....	12	14
Durable Manufacturing			Nonmetallic minerals [327].....	19	23
Wood products [321].....	12	12	Primary metal[331].....	27	32
Nonmetallic minerals [327].....	19	20	Fabricated metal [332].....	24	29
Primary metal[331]	27	28	Machinery[333].....	25	30
Fabricated metal [332].....	24	25	Computer/ electronic product [334]	14	17
Machinery[333].....	25	26	Electronic equipment/	14	17
Computer/ electronic product [334]	14	15	Transportation equipment		
Electronic equipment/	14	15	Motor vehicle,, body, trailers and equipment.....	14	17
Transportation equipment			Other transportation equipment [3364-3366, 3369].....		
Motor vehicle,, body, trailers and equipment.....					
parts [3361-3364]					
Motor vehicle,, body, trailers and equipment parts [3361-3364].....	14	15			
Other transportation equipment [3364-3366, 3369].....	17	18	Furniture and related products [337]	14	17
Furniture and related products [337]	14	15	Miscellaneous Mfg. [339]		
Miscellaneous Mfg. [339]			Medical equipment/ supplies[3391]	14	17
Medical equipment/ supplies[3391]	14	15	Other miscellaneous [3399]	17	20
Other miscellaneous [3399].....	17	18	Nondurable Manufacturing		
Nondurable Manufacturing			Food [311].....	20	24
Food [311].....	20	21	Beverage and tobacco product[312]..	21	25
Beverage and tobacco product[312]..	21	22	Textile mill and textile mill products [313, 314].....	16	19
Textile mill and textile mill products [313, 314].....	16	17	Apparel and leather and allied products [315, 316].....	15	18
Apparel and leather and allied products [315, 316].....	15	16	Paper products [322].....	16	19
Paper products [322].....	16	17	Printing and related supported activities [323].....	15	18
Printing and related supported activities [323].....	15	16	Petroleum and coal products [324]...	22	26
Petroleum and coal products [324]...	22	23	Chemical products.....	16	19
Chemical products [325].....	16	17	Plastic and rubber products [326].....	14	17
Plastic and rubber products [326].....	14	15	Nonmanufacturing industries.....	16	19
Nonmanufacturing industries.....	16	17	Office and accounting machinery (14)		
Special industry machinery, n.e.c (12)::			Years before 1978.....	8	7
Durable Manufacturing			1978.....	7	6
Wood products [321].....	12	15	Service industry machinery (15):		
Nonmetallic minerals [327].....	19	24	Wholesale and retail trade [42,44-45].	10	12
Primary metal[331]	27	33	All other industries.....	11	13
Fabricated metal [332].....	24	30	Communications equipment (16):		
Machinery[333].....	25	31	Broadcasting & Communications[513]	11	13
Computer/ electronic product [334]	14	17	All other industries.....	15	19
Electronic equipment appliance [335]	14	17	Electrical transmission, distribution, and industrial apparatus (17).....	33	41
Transportation equipment			Household appliances (18).....	10	12
Motor vehicle,, body, trailers and equipment.....	14	17	Other electrical equipment (19).....	9	11
parts [3361-3364].....			Light trucks, incl. utility vehicles (20)		
Other transportation equipment [3364-3366, 3369].....	17	21	Years before 1992		
Furniture and related products [337]	14	17	Transit and ground passenger	14	17
Miscellaneous Mfg. [339]	14	17	Transportation [485]	10	12
Medical equipment/ supplies[3391]	17	21	Trucking transportation [484]	9	10
Other miscellaneous [3399].....	20	25	All other industries	17	10
Nondurable Manufacturing			Other trucks, buses, trailers (21)		
Food [311].....	21	26	Transit and ground passenger transportation [485].....		
Beverage and tobacco product[312]..			Trucking transportation [484].....	14	17
Textile mill and textile mill products [313, 314].....	16	20	Other industries.....	10	12
				9	10

Table 1. BEA and BLS Mean Asset Service Lives - Continued

Type of asset (BLS Asset No.) [NAICS]	Service Life (years)		Type of asset (BLS Asset No.) [NAICS]	Service Life (years)	
	BEA	BLS		BEA	BLS
Autos (22)	n.a.	9	Private nonresidential structures		
Aircraft (23):			Petroleum pipelines (57)	40	73
Years before 1960:			Farm (58)	38	72
<i>Air transportation [481]; Depository credit intermediates [5221]; Activities related to credit intermediation [5223]; Rental and leasing services and lessor of intangible assets [532] ..</i>	16	20	Mining structures		
<i>All other industries</i>	12	15	Petroleum and natural gas (59):		
1960 and years beyond:			Years before 1973	16	33
<i>Air transportation [481]; Rail transportation [482]; Depository credit intermediates [5221]; Activities related to credit intermediation [5223]; Insurance agencies and brokers and related services [5243]; Funds, trusts, and other financial vehicles [525]; Rental and leasing services and lessor of intangible assets [532]; Management of companies and enterprises [5511]; Offices of other holding companies and auxiliaries [5512]</i>	25	31	1973 and beyond	12	25
<i>All other industries</i>	15	19	Other Mining (60)	20	40
Ships and boats (24)	27	33	Medical building (61)	36	70
Railroad equipment (25)	28	35	Railroad replacement track (62)	38	69
Photocopying and related equipment (26) ..	9	11	Wind and Solar (63)	30	58
Medical equipment & related Instruments (27)	12	15	Special Care (82)	48	90
Electromedical instruments (28)	9	11	Multimerchandise shopping (83)	34	66
Nonmedical instruments (29)	12	15	Food and beverage establishments (84)	34	66
Other Nonresidential Equipment (30)	11	14	Religious buildings (85)	48	90
Nuclear fuel (31)	n.a.	4	Mobile offices (86)	16	33
Mainframe computers (32):			Other transportation (87)	38	73
Years before 1970	n.a.	9	Other land transportation (88)	38	73
1970 to 1979	n.a.	7	Water Supply (89)	40	76
1980 and years beyond	n.a.	5	Sewage and Waste Disposal (90)	40	76
Personal computers (33)	n.a.	5	Public Safety (94)	38	73
Direct access storage devices (34):			Highway and Conservation and Development (95)	40	76
Years before 1986	n.a.	8			
1986 and years beyond	n.a.	9	Tenant-occupied, residential capital		
Printers (35):			Tenant-occ. manufactured homes (64)	20	20
Years before 1976	n.a.	10	Tenant-occupied, 1-4 units, new (65)	80	80
1976 to 1980	n.a.	8	Tenant-occupied, 1-4 units, additions and alterations (66)	40	40
1981 to 1985	n.a.	6	Tenant-occupied, 1-4 units, major replacements (67)	25	25
1986 and years beyond	n.a.	5	Tenant-occupied, 5+ units, new (68)	65	65
Terminals (36):			Tenant-occupied, 5+ units, additions and alterations (69)	32	32
Years before 1981	n.a.	9	Tenant-occupied, 5+ units, major replacements (70)	20	20
1981 to 1985	n.a.	8	Tenant-occupied, 1-4 units, equipment (71)	11	13
1986 and years beyond	n.a.	6	Tenant-occupied, 5+ units, equipment (72)	11	13
Tape drives (37):			Tenant-occupied, acquisition costs (96) ...	n.a.	13
Years before 1981	n.a.	9	Tenant-occupied, disposal costs (97)	n.a.	13
1981 and years beyond	n.a.	7			
Storage devices (38)	n.a.	5	Intellectual Property Products		
Integrated systems (39)	n.a.	5	Software, pre-packaged (40)	3	3
Private nonresidential structures			Software, custom (41)	5	5
Manufacturing (43)	31	56	Software, own-account (42)	5	5
Office buildings	36	70	Research and Development [R&D](100)		
Commercial warehouses (45)	40	77	An aggregate of the following R&D assets: rd11, rd12, rd21, rd22, rd23, rd24, rd25, rd31, rd32, rdom, rd70, rd40, rd50, rd60, and rd80.	n/a	n/a
Other commercial buildings (46)	34	66			
Educational buildings (47)	48	90	Entertainment, Literary, and Artistic Originals. An aggregate of the following BEA ELA Originals: ae10, ae21, ae22, ae30, ae41, ae42, ae51, ae52, and a53.	n/a	n/a
Hospitals (48)	48	90			
Hotels and motels—Lodging (49)	32	62			
Amusement & recreational buildings (50) ..	30	59			
Air transportation (51)	38	73			
Other railroad structures (52)	54	95			
Communications (53)	40	73			
Electric (54):					
Years before 1946	40	73			
1946 and beyond	45	81			
Gas (55)	40	73			
Local transit (56)	38	73			

BLS estimates of productive capital stocks for equipment, structures, and intellectual property products are based on detailed gross investment data from BEA and on estimates of how capital service flows "deteriorate" as assets age. Chart 1 shows the gross investments of the broad asset categories of equipment, structures, and intellectual property products from 1987. BEA provides estimates of rates of economic "depreciation". Deterioration and depreciation are not the same thing but they are closely related. Depreciation is the loss in value associated with deterioration. In the BLS model, depreciation occurs more rapidly than deterioration during the earlier years of an asset's service life. BLS has adjusted its deterioration estimates for equipment and nonresidential structures to ensure consistency with BEA depreciation rates. The BLS deterioration estimates were generated by selecting longer service lives than the BEA estimates. Table 1 presents a list of the asset types, together with service life estimates, which BLS has adopted. These are compared with a list of the asset types and service lives which BEA uses. (The BLS also estimates productive stocks of inventories and land using different data sources and procedures.)

Table 1 shows BLS service lives of nonresidential structures that have been adjusted to BEA depreciation rates to be much longer than BEA's service lives. While BLS finds that adapting to BEA depreciation rates yields reasonable estimates for the service lives of nonresidential structures, the same does not hold true for residential structures. BLS service lives of residential structures adjusted to BEA depreciation rates could be as long as 150 years. Therefore, BLS uses the unadjusted BEA service lives for residential structures.

Once productive capital stocks have been calculated for the various types of assets used by an industry, they are aggregated into indexes representing the industry's total capital services. This is the second step in arriving at aggregate capital measures. This is accomplished by estimating "implicit rental prices" for each type of asset and then using these rental prices to construct Tornqvist aggregates of the productive stocks. The rental prices are designed to account for differences in the service flows of assets of different types. The BLS rental price estimates take account of the rate of return to capital, the rate of economic depreciation, the rate of nominal appreciation of assets and also the tax treatment of assets. The use of rental prices to construct weights for aggregation is an important step in measuring capital services, because in large part rental prices differ because of dissimilar depreciation rates and rental prices take proper account of all of the implications of depreciation for these services. In the discussion of the empirical results below, it will be seen that weights did not change much except for land, which does not have a depreciation term. This was because changes to the rental prices tend to offset changes in the levels of productive stocks.

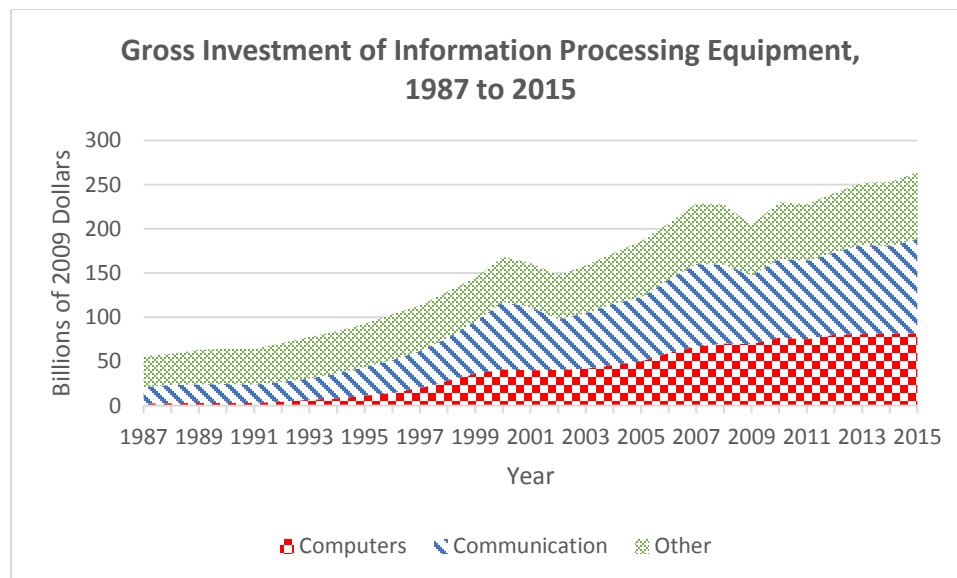
The third and final step in major sector capital measurement is the aggregation of industry capital services to the level of private business and private nonfarm business sectors. At this stage of aggregation, the weight assigned to each industry's capital input is the industry's share of its capital income in the total capital income of the aggregate sector. Capital income estimates are based on selected components of nominal income from BEA's work on gross product originating by industry; namely, the other gross operating surplus and its corporate and non-corporate components.

BLS uses these NIPA-level industry capital service measures to calculate all of its major sector and NIPA-level multifactor productivity estimates. BLS currently publishes news releases for the private business and private nonfarm business sectors and for the major manufacturing sectors and for 18 NIPA-level manufacturing industries. BLS also publishes two sets of additional multifactor productivity measures that are currently available. One measure includes multifactor productivity for 42 three-digit NAICS nonmanufacturing industries. The second set includes value-added output per combined input measures for the total economy.

Information processing equipment

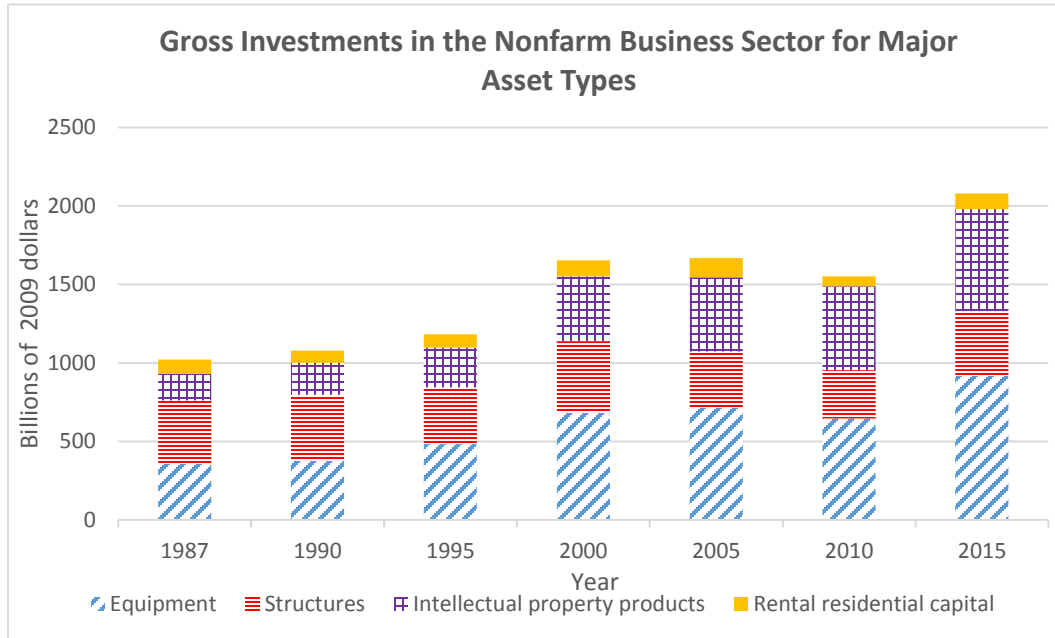
Information processing equipment is composed of three broad classes: computers and related equipment, communications equipment, and other information processing equipment. Computers and related equipment includes mainframe computers, personal computers, printers, terminals, tape drives, storage devices, and integrated systems. Communications equipment is not further differentiated. Other information processing equipment includes medical equipment and related instruments, nonmedical instruments, photocopying and related equipment, and office and accounting machinery. Originally included in the 1999 Comprehensive Revision of the NIPA as being part of the information processing equipment asset category, software investments have now been re-classified as being part of the intellectual property products category in the 2013 Comprehensive Revision of the NIPA. Chart 1 shows the gross investments of three broad categories of information processing equipment in the private nonfarm business sector starting from 1987 and the increasing share of computers in the total gross investment of information processing equipment

Chart 1. Composition of Gross Investment in Information Processing Equipment in the Nonfarm Business Sector, 1987 to 2015.



A growing professional and public interest on the role of technology and its influence on productivity growth has compelled BLS to create a broad new category of assets that embody this technology. Chart 2 illustrates the composition of the gross investments (in billions of 2009 dollars) in the nonfarm business sector by major asset groups for selected years.

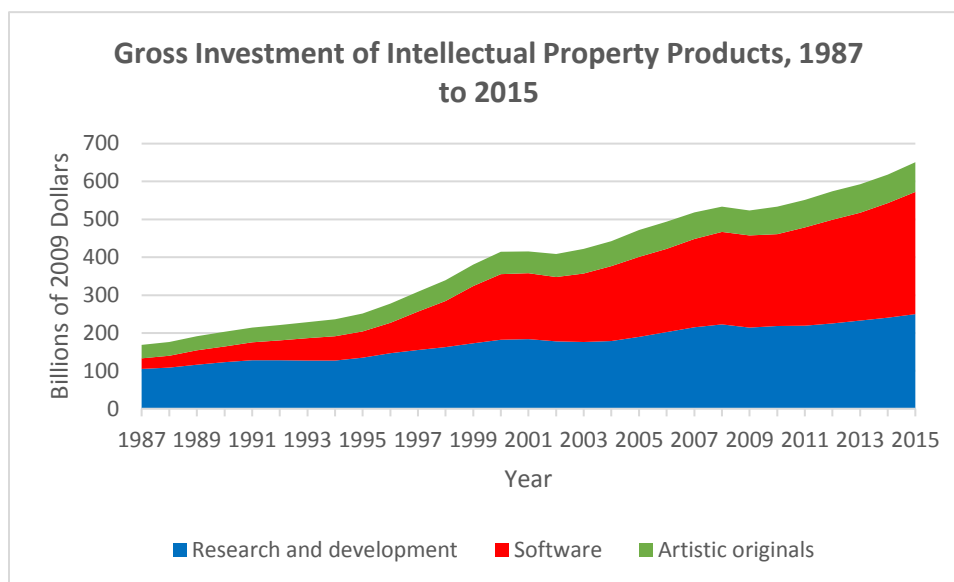
Chart 2. Distribution of Gross Investments in the Nonfarm Business Sector by Major Asset Types selected years



Intellectual Property Products

In the 2013 Comprehensive Revision of the NIPA, BEA introduced a new major asset category called “intellectual property products” that grouped a variety of intangible fixed assets that now include software and databases, research and development, and entertainment, literary, and artistic originals. According to the 2008 Statistics of National Accounts (SNA), “Intellectual property products are the result of research, development, investigation, or innovation leading to knowledge that the developers can market or use to their own benefit in production because use of the knowledge is restricted by means of legal or other protection.” BEA asserts that these intellectual property products have characteristics similar to tangible fixed assets; mainly, that they have ownership rights, are long-lasting, and have the potential to be used repeatedly in the production process. Chart 3 illustrates gross investments of the three broad categories of intellectual property products from 1987 and the increasing share of software as part of the gross investment for intellectual property products.

Chart 3. Composition of Gross Investment in Intellectual Property Products in the Private Nonfarm Business Sector, 1987 to 2015.



In the 1999 Comprehensive Revision of the NIPA, business and government expenditures for computer software were recognized as fixed investments for the first time (Moulton, Parker, and Seskin, 1999). Parker (2000) listed three types of software being treated as investments: prepackaged, custom and own account. Prepackaged software is defined as software intended for non-specialized use that comes in a standardized format. Custom software is software specifically written to the specifications of a buyer. Own-account software is software that has been created or enhanced by business or government for their own use. Prior to the 2013 Comprehensive Revision of the NIPA, software assets were classified under the equipment category.

According to the 1993 SNA, “Research and development consists of the value of expenditures on creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and use of this stock of knowledge, including knowledge of man, culture and society, and use of this stock of knowledge to devise new applications. This does not extend to human capital as assets within the SNA.” BEA currently has seventeen detailed research and development asset categories that BLS has aggregated into a single research and development series. Entertainment, literary, and artistic originals are described by the SNA (1993) as consisting of “...original films, sound recordings, manuscripts, tapes, models, etc., on which drama performances, radio and television programming, musical performances, sporting events, literary and artistic output, etc., are recorded or embodied.” Among the items that BEA has defined as originals are theatrical movies, long-lived television programs, books, music, theatrical scripts, greeting card designs, and commercial stock photography. Starting from the implementation of the 2013 Comprehensive Revision of the NIPA, BEA will treat any private expenditures associated with the producing or purchasing of entertainment, literary, and artistic originals as private fixed investment when measuring GDP. As with BEA’s detailed research and development assets, BLS has aggregated BEA’s nine detailed assets related to entertainment, literary, and artistic originals into a single series.

New nonresidential structures

The 2009 Comprehensive Revision of the National Income and Products Accounts introduced following non-residential structures: special care, multimerchandise shopping, food and beverage establishments, water supply, sewage disposal, public safety, and highway and conservation and development.

New residential investments

In the 2013 Comprehensive Revision of the NIPA, BEA recognized "ownership transfer costs," the expenses associated with the acquisition or disposal of fixed residential assets as gross investment in residential structures. Examples of these ownership transfer costs include closing costs other than those associated with getting a mortgage, payments for state and local documentary and stamp taxes, and payments for surveys and engineering services. Expenses associated with obtaining financing for the purpose of obtaining a residential asset such as loan association fees and credit reports will not be considered part of gross investment in residential structures.

Changes in measures of depreciation

Since 1996 BEA has used *geometric depreciation* rates that imply that an asset's value declines at the same *percentage rate* each year. As noted by Fraumeni (1997), depreciation schedules reflect the underlying values that assets can contribute to production over the remainder of their lives. BLS, on the other hand, assumes that an asset's value depreciates less rapidly during the initial years of an asset's service life. This assumption is based on limited empirical evidence and anecdotal observations that such a pattern of depreciation is more realistic for many types of assets. Such observations led the BLS to postulate concave depreciation schedule patterns that conform to the assumption that assets do not decay rapidly during their initial years. These concave depreciation schedule patterns are revised to be consistent with new evidence on the depreciation rates gathered by BEA (Harper, 1999).

Ideally, depreciation profiles are estimated based on the market prices of used assets. For most assets, markets for used assets are either non-existent or too inactive to generate reliable age-price profiles. However, BEA was able to estimate age-price profiles for computers and computer peripherals from work by Oliner [1993] as well as for autos. For other assets, BEA has estimated geometric depreciation rates using evidence from a number of empirical studies. The new rates were obtained by dividing "declining balance" parameters by BEA's previous estimates of the assets' service lives. Based on the evidence, BEA selected parameters of 1.65 for equipment and .91 for structures. This approach, which draws on work by Hulten and Wykoff [1981a, 1981b] effectively makes broad adjustments to the previous BEA depreciation assumptions based on evidence from a limited number of asset categories. With the 0.91 parameter, the resulting depreciation rates for nonresidential structures turn out to be quite low. As a consequence of the low depreciation rates, the BEA stocks of nonresidential structures are much larger than they were in previous measures.

While the Hulten and Wykoff studies represent the best available empirical evidence on the depreciation rates of nonresidential structures, there are several reasons to be cautious about their estimates. Unlike equipment, no two buildings are identical. The price of a building depends on the quality and size of construction, tax treatment, location and a host of other characteristics. However, accurate measures of economic depreciation depend on measuring the price change of an asset as it ages, holding all other characteristics constant. The work by Hulten and Wykoff was largely unable to control for the effect of these other traits on prices. In particular, as a city or urban area expands outward, the value of an older building may increase as the location becomes more valuable. This would appear to lower the rate of price decline for older buildings. Furthermore, the studies examined building prices in the 1970s. There may have been an unusual amount of appreciation in used real estate prices during this period; they had very little effect on the trend in MFP. Work is currently underway at BLS to examine depreciation using more current information from Statistics Canada surveys.

Summary

The Bureau of Labor Statistics has updated its existing capital input measures to reflect changes to BEA's fixed investments due to BEA's 2013 Comprehensive Revision. BLS now includes intellectual property products and two new residential assets due to the Comprehensive Revision as part of its capital inputs. Intellectual property products' share of gross investment has continued to increase, now second only to equipment.

BLS incorporates BEA fixed asset investment into its estimates of productive stocks by adjusting service lives so they are consistent with BEA economic depreciation estimates. BLS adjusts service lives for equipment, nonresidential structures, and intellectual property products but not for residential structures. BLS then uses its estimates of productive stock to estimate capital services, the input that BLS uses in estimating productivity. As new categories of gross investment data become available and novel estimation procedures are developed, BLS will continue to enhance its capital input measures.

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