CHAPTER 7

INFLATION

I. Introduction

The performance of economic analysis requires that benefits and costs be measured. The yardstick of measurement is the dollar. This yardstick must remain unchanged for all quantities measured if resulting measurements are to be meaningful and comparable with each other. But the value of the dollar is rarely constant from one year to the next. Changes in the prices of goods and services continuously effect the purchasing power of the dollar. This chapter deals with how to manage changes in the value of the dollar over time in order that benefits and costs occurring in different years may be consistently measured.

II. Price Changes

This section is divided into two parts: measuring inflation and measuring price changes for specific commodities. Inflation may be defined as a change in the general price level--this is, a change in the average price of all goods and services produced in the economy or which are regularly purchased by a defined buyer or class of buyers. It is conceptually distinct from the change in the price of any specific commodity, which most likely will be changing at a different rate than the price level or even moving in the opposite direction.

A. Measuring Inflation

Changes in the value of the dollar over time are measured using an index number. For the overall U.S. economy, a broadly based index representing the price of all goods and services such as the Gross Domestic Product (GDP) Implicit Price Deflator is commonly used. When considering the goods and services typically bought by a subset of purchasers, such as households, a more narrowly defined index representing the price of these particular commodities such as the Consumer Price Index is typically employed. Such numbers are a measure of relative value. They indicate the price of the group of goods and services of interest in one year relative to some other year. By convention, index numbers are usually computed as the ratio of the price of the goods and services of interest in one year divided by their price in the base year. The resulting ratio is then multiplied by 100 to produce the index number. Repeating the process for a number of years results in a series of index numbers.

To illustrate the methodology of working with index numbers, consider the two price measures for GDP reported in Table 7-1: The GDP Implicit Price Deflator and the GDP Chain-Type Price Index. Both measures are currently published by the Bureau of Economic Analysis of the Department of Commerce. Because the two series differ only slightly, it is appropriate to use either. The following examples make reference to the deflator series.

Note first that 1992 has a value of 100. Known as the base year, it is an arbitrary selection which is changed from time to time. It indicates that all other values are measured relative to 1992 being equal to 100.

TABLE 7-1

GROSS DOMESTIC PRODUCT IMPLICIT PRICE DEFLATOR on a CHAIN-WEIGHTED BASIS and GROSS DOMESTIC PRODUCT CHAIN-TYPE PRICE INDEX
(1986 - 1996)

YEAR	GDP CHAIN-TYPE PRICE INDEX	GDP IMPLICIT PRICE DEFLATOR
1986	80.6	80.6
1987	83.1	83.1
1988	86.1	86.1
1989	89.7	89.7
1990	93.6	93.6
1991	97.3	97.3
1992	100.0	100.0
1993	102.6	102.6
1994	105.0	104.9
1995	107.6	107.6
1996	109.9	109.7

Source: *Survey of Current Business*, Bureau of Economic Analysis, Department of Commerce, published monthly. In addition, GDP Implicit Price Deflators and Chain-Type Price Indexes are regularly reprinted in the *Economic Report of the President*, published annually and *Economic Indicators*, prepared for the Joint Economic Committee by the Council of Economic Advisers, published monthly.

For example, the 1994 value of the GDP implicit price deflator of 104.9 means that the price level for a given basket of goods and services in 1994 was 4.9 percent higher than it was in 1992, which is readily apparent from inspection. Given the 1992 base, it is not readily apparent, how much greater the price level was in 1993 than in 1987. This can be easily computed as 23.5 percent by dividing the 1993 value by the 1987 value and subtracting 1: (102.6/83.1)-1 = 23.5%. Moreover, the entire index may be restated in terms of any other base year by dividing each value by that of the new base year.[1] Annual changes may be computed by dividing each value by that of the previous year and subtracting 1. For example, the rate of price change between 1995 and 1994 is: (107.6/104.9)-1 = 2.57%.

To make adjustments for general price level changes requires that the concepts of constant dollars and current dollars be recognized. Current dollar estimates are expressed in the price level of the year in which the resource flows they represent occur. They are the actual amount spent or received. Constant dollar estimates represent the same value as current dollar estimates but as measured by the yardstick of the price level of a fixed reference year. Constant dollars can be specified in terms of any reference year that is desired.

To convert a series expressed in current dollars to constant dollars of a particular year requires that all numbers in the series be adjusted for general price level changes. This requires two steps. First, the general price level index must be transformed so that its base year is the one in which the constant dollars are to be stated. As previously noted, this is accomplished by dividing the general price level index through by its value in the desired base year. The second step is to convert the specified price series to constant dollars. This requires that it be divided by the values produced by step 1. The procedure is illustrated in Table 7-2, where the total FAA Operations and Maintenance Budget Appropriation from 1986 through 1996 is converted from current dollars to 1995 constant dollars. To convert constant dollars to current dollars requires that the procedure be reversed. First the deflator series must be divided by its value in the year in which the constant dollars are expressed and multiplied by the constant dollar series.

Another conversion likely to be encountered in practice is the transformation of a series from the constant dollars of one year to those of another. This is accomplished by multiplying the constant dollar series by the ratio of the price index term for the desired year to the price index term for the year in which it is currently expressed, where the base year of the price index is arbitrary. For example, to convert the 1995 constant dollar series in column (4) of Table 7-2 from 1995 constant dollars to 1990 constant dollars requires that each number in column (4) be multiplied by 87.0/100 from column (2) or 93.6/107.6 from column (1).

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1 Restating an index in terms of another base year is a simple arithmetic calculation. It is not the same as the complex statistical processes typically involved when the entity which generates an index officially changes its base year. Such a change involves many technical adjustments which may include changes in scope of coverage and weighting schemes.

TABLE 7-2

CONVERSION of FAA OPERATIONS and MAINTENANCE APPROPRIATIONS from CURRENT DOLLARS to CONSTANT DOLLARS

(Dollars in Millions)

Year	(1) GDP Deflator (1992 =100)	(2) GDP Deflator (1995 = 100)[a]	(3) Total O&M Appropriations in Current Dollars	(4) Total O&M Appropriations in 1995 Constant dollars[b]	(5) Total O&M Appropriations in 1990 Constant dollars[c]
1986	80.6	74.9	2,808	3,749	3,262
1987	83.1	77.2	2,982	3,863	3,361
1988	86.1	80.0	3,184	3,980	3,463
1989	89.7	83.4	3,445	4,131	3,594
1990	93.6	87.0	3,824	4,395	3,824
1991	97.3	90.4	4,037	4,466	3,885
1992	100.0	92.9	4,360	4,693	4,083
1993	102.6	95.4	4,538	4,757	4,139
1994	104.9	97.5	4,580	4,697	4,086
1995	107.6	100	4,583	4,583	3,987
1996	109.7	102.0	4,643	4,552	3,960

Source: *Economic Report of the President*, published annually; *"Federal Aviation Administration Budget in Brief,"* Fiscal Year 1998.

a. Divide column (1) by 107.6 and multiply by 100.

b. Column (3) divided by column (2) and multiplied by 100.

c. Column (4) multiplied by 87.0 / 100.

B. Measuring Price Changes of Specific Goods and Services

A related but distinct situation arises when it is necessary to convert the price of a specific item which is known in one time period to what it was in the past or will be in the future. For past prices, this may be accomplished by using an historical price index defined for the particular class of item in question. For example, suppose it is known that a particular generic kind of aircraft was worth $2 million dollars in 1995. A price index defined for this general type of aircraft allows us to determine--using the procedures described above in Section II. A.--that the price of this aircraft has doubled since 1985. We can then estimate the price of this aircraft in 1985 as $1 million. Note that this price adjustment provides no information as to whether this aircraft's price has increased faster than, slower than, or at a rate equal to the overall rate of inflation during this time period.

An estimate of the future price of an item may be made by using a forecast of a price index for the class of item to determine expected change in the price of the item and then adjusting the current price of the item. In the absence of a price index forecast defined for the class of item of interest, it may be necessary to use a broader index for a particular segment of the economy or in some circumstances a general measure of inflation such as the GDP deflator. While data limitations may require use of the broader measure, it must be recognized that in so doing information on changes in the price of the item relative to the general price level may not be totally or even partially captured.

Estimation of prices of items in the future are typically made for two reasons. The first is for budget purposes. It is necessary to know how much will actually be spent in the future so that it may be budgeted for and included in the appropriation process. The second occurs in the conduct of benefit-cost analysis where it is necessary to determine expected benefit or cost value changes relative to changes in the general price level. This can be particularly important when dealing with items which are a large component of the analysis and which have price changes that differ significantly from the overall change in the general price level. Of particular importance in FAA benefit-cost analyses is the decrease in the cost of electronics relative to the general price level. Suggested methods for dealing with this type of problem are presented in Section IV. C. below.

III. Sources of Price Indexes

Numerous different price indexes and forecasts of price indexes are published by governmental and private organizations. They are available for many narrowly defined commodities and services, as well as for broader classifications ranging in scope from selected 4-digit SIC Code[2] industries to the overall economy.

Available information and the specific situation should govern the selection of an index for any particular price adjustment problem. In general, broadly based measures which reflect the prices of all goods and services typically purchased by a specific buyer or class of buyer should be used to make adjustments for inflation--changes in the general level of

[2] Industries are classified in the *Standard Industrial Classification Manual 1987*, Office of Management and Budget, 1987. The classification system operates in such a way that the definitions become progressively narrower with successive additions of numerical digits. The broadest classifications contain 2 digits and the narrowest 7 digits.

prices. Narrowly defined measures are appropriate for estimating past or future prices of specific goods or services. Special care should be taken not to use a narrowly defined index to make adjustments for the general level of inflation. For instance, if the objective is to determine the change in the real price of aircraft over time (as measured relative to other goods and services), it would not be appropriate to deflate an historical time series of aircraft prices by an aircraft price index. The aircraft price index is built from historical aircraft price changes, and its subsequent application to an historical series of aircraft prices would (by definition) give the impression that aircraft prices remained constant. In fact, prices of aircraft may have changed significantly relative to prices of other goods and services in the economy. It would be appropriate to use an index composed of a broad mix of goods and services (such as the implicit GDP deflator), of which aircraft prices are only a small part, to deflate aircraft prices. On the other hand, if the objective is to convert a known aircraft price from an earlier year to a current aircraft price in the study year, the use of an aircraft price index would be appropriate.

The following section identifies several indexes that may be of use to agency analysts. They are organized by categories relevant to potential FAA economic analyses. These indexes are intended only as suggestions.

A. General Price Level

In January 1996 the Bureau of Economic Analysis, compelled by recent dramatic changes in the U.S. economy's structure (particularly the spectacular fall in computer prices), adopted a chain-weighted method of computing real GDP and aggregate growth.[3] Associated with this new approach is the GDP Chain-Type Price Index. Both the new GDP Chain-Type Price Index and the older GDP Implicit Price Deflator represent changes in the prices of all goods and services produced in the United States. Because of their broad coverage, they are widely regarded as the best single measures of changes in the general price level. Either may be used to adjust time series data on current dollar benefits and costs into constant dollars. These measures are compiled by the Bureau of Economic Analysis on a quarterly and annual basis. Data for the most recent three years are published in the *Survey of Current Business.*[4] Historical data are reprinted in the

[3] For a general discussion of the chain-type method, see Charles Steindel, "Chain-Weighting: The New Approach to Measuring GDP", *Current Issues in Economics and Finance*, Vol. 1, Number 9, Federal Reserve Bank of New York, December 1995, pp. 1-5. A more detailed description is given in Mark Lasky, "Forecasting with the New Data", *DRI/McGraw-Hill U.S. Review*, February 1996, pp. 38-50, and Mark Lasky "A Preview of the New Chain-Weighted GDP Measures", *DRI/McGraw-Hill U.S. Review*, September 1995, pp. 29-37.

[4] *Survey of Current Business*, Bureau of Economic Analysis, Department of Commerce, Washington, D.C., published monthly.

Economic Indicators.[5] Both series is also reprinted annually in the *Economic Report of the President*.[6]

Forecasts for the GDP Implicit Price Deflator and/or GDP Chain-Type Price Index are available from several sources. The Office of Management and Budget provides a projection of the GDP Implicit Price Deflator annually in conjunction with the preparation of the President's Budget. DRI/McGraw-Hill Data Resources provides forecasts of a wide range of deflators and indexes. The WEFA Group, another full-service economic and information consulting firm, also provides a broad range of services including forecasts of deflators and indexes. OMB recommends that the GDP deflator projections prepared in conjunction with the President's Budget be used when it is necessary to forecast the rate of general inflation and that credible private sector forecasts be used to conduct sensitivity analysis.[7]

B. Economic Sector Price Levels

Price levels of sectors of the economy represented by the various components of Gross Domestic Product are measured by either the respective deflator for each component or the respective chain-weighted index. Component deflators or component chain-weighted indexes likely to be of interest to agency analysts are those for total personal consumption expenditures, fixed investment, nonresidential structures, and government purchases of goods and services. They are published in the same sources as the GDP Deflator and Chain-Type Price Index. Historical data on a chain-weighted basis are available back to 1959. Forecasts of these series are available from the same sources as the GDP Deflator and Chain-Type Price Index. (Section III. A., page 10).

C. Construction

Several widely known indexes of construction costs are available in addition to the implicit deflator. The Boeckh Building Cost Index is compiled monthly by E.H. Boeckh Company, the property division of Mitchell International (internet address: http://www.mitchell.com/boeckh/bcontact.html). It represents construction costs for three types of buildings: (1) apartments, hotels, and office buildings, (2) commercial and factory buildings, and (3) residential buildings. The *Engineering-News Record* (ENR) publishes monthly its Construction Cost, Common Labor, Skilled Labor, Building Cost

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5 *Economic Indicators*, prepared for the Joint Economic Committee by the Council of Economic Advisers, U.S. Government Printing Office, Washington, 1996, published monthly.

6 *Economic Report of the President*, Council of Economic Advisers, Washington, D.C., published annually in January.

7 OMB Circular A-94 (Revised--October 29, 1992) p. 8.

and Material Cost (comprised of cement, steel and lumber) Indexes. These indexes are available separately for 20 U.S. cities. In addition, the ENR uses the Department of Commerce fixed-weighted Construction Cost index to deflate the value of New Construction Put-In-Place to constant 1992 dollars. On a quarterly basis, the ENR compiles various construction cost indexes : general-purpose cost, valuation, and special-purpose indexes. Each December the ENR forecasts these indexes for the next 12 months.[8]

The Federal Highway Administration publishes a quarterly index of highway construction costs in "Price Trends for Federal-Aid Highway Construction."[9] It is based on pricing of six components of highway construction: common excavation, to indicate the price trend for all roadway excavation; Portland cement concrete pavement and bituminous concrete pavement, to indicate the price trend for all surfacing types; and reinforcing steel, structural steel, and structural concrete, to indicate the price trend for structures.

D. Energy

As a component of the Producer Price Index (PPI), the Bureau of Labor Statistics compiles monthly indexes for the prices of coal, coke, gas fuels, electric power, crude petroleum, and refined petroleum products--gasoline, kerosene and jet fuels, light fuel oils, residual fuels--as well as a composite of them. These are published in the *PPI Detailed Report*[10] or in *The Monthly Labor Review*.[11] The PPI indexes are also available on the BLS web site at http://stats.bls.gov.

In addition, the Energy Information Administration of the U.S. Department of Energy , publishes the *Annual Energy Review* and *Annual Energy Outlook*. For most series, historical energy statistics are given from 1949 through the current year. The *Annual Energy Outlook* contains projections to 2015. Most of the data are also available electronically at http://www.eia.doe.gov.

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[8] For a detailed description of the index, see "Materials and Labor Cost Trends in the U.S.," *Engineering News-Record*, (March 9, 1981); pp. 132-137. Also see fourth quarterly Cost Report in ENR for December 23, 1996, and Forecast' 97 in ENR for January 27, 1997.

[9] "Price Trends for Federal-Aid Highway Construction," Office of Engineering, Federal-Aid and Design Division, Federal Highway Administration, publication number FHWA-PD-95-006.

[10] *The PPI Detailed Report*, Bureau of Labor Statistics, Department of Labor, published monthly.

[11] *The Monthly Labor Review*, Bureau of Labor Statistics, Department of Labor, published monthly.

E. Electronics and Computers

Also contained in the Producer Price Indexes are several components representing electric and electronic devices. The broadest category is for electrical machinery and equipment. It represents such items as wiring devices, instruments, motors, transformers, switching gear, electric lamps, and electronic components and accessories. An index for each of these subcomponents is also available. The electric and electronic devices index is published in the *Monthly Labor Review* and the subcomponent indexes in the monthly *PPI Detailed Report.*[12] In addition, the monthly *PPI Detailed Report* provides indexes for specific SIC electronics industries--electron tubes (SIC 3671), printed circuit boards (SIC 3672), semiconductors (SIC 3674), electronic capacitors (SIC 3675), electronic resistors (SIC 3676), electronic coils and transformers (SIC 3677) and electronic connectors (SIC 3678). Computers are aggregated under a broad category--Office, Computing, and Accounting Machines (SIC 357). At the four-digit level, the computer industry is represented in the PPI by electronic computers (SIC 3571), computer storage devices (SIC 3572), computer terminals (SIC 3575), and computer peripheral equipment, n.e.c. (SIC 3578).

F. Aircraft and Parts

In addition, BLS publishes the PPI indexes for aircraft and parts. These consist of an aggregate index for aircraft and parts (SIC 372) and more detailed indexes: aircraft (SIC 3721), aircraft engine and engine parts (SIC 3724), and aircraft parts and auxiliary equipment, n.e.c. (SIC 3728). DRI provides a forecast of these indexes upon customer request.

IV. Treatment of Inflation in Benefit-Cost Analysis

As a general rule, inflation should not be permitted to affect the outcome of benefit-cost analyses. Such studies are concerned with real quantities--resources consumed and benefits provided. The dollar is used only as the yardstick of value measurement. Because changes in the unit of measurement cannot affect the relationship between the real quantities, allowing price changes to affect the analysis will distort the results. This section presents methodology for ensuring that inflation does not impact benefit-cost analyses and produce such distortions.

A. Constant or Nominal Dollars

[12] *The PPI Detailed Report*, Bureau of Labor Statistics, Department of Labor, published monthly.

OMB now permits benefit-cost analyses to be conducted in either nominal or current dollars or in constant dollars of a particular year.[13] Effects of inflation are excluded by choosing *either* nominal dollars *or* constant dollars and avoiding mixing-up both in the same analysis and by using a nominal discount rate if the analysis is conducted in nominal dollars and a real discount rate if the analysis is conducted in constant dollars. (See Chapter 5, II. C.) OMB implies a preference for the use of constant dollars unless most of the underlying values are initially available in nominal dollars. Although some conversion from nominal to constant or vice-versa may be necessary to get all values into one form or the other, the choice of nominal or constant dollars should be made so as to minimize the conversions required.

Another consideration in selecting nominal or constant dollars is whether or not private sector optimizing behavior is endogenous within the analysis to be undertaken. If it is, the analyst must recognize that private sector actions are based on after tax impacts and that taxes are typically a function of nominal values. (For example, an analysis of alternative policies designed to influence aircraft operators to replace older aircraft with newer, quieter ones would need to incorporate tax impacts of replacement.) Where the outcome of an analysis depends significantly on such behavior, the analyst should seriously consider use of nominal values when designing the study.

Current FAA practice is to conduct benefit-cost analyses in constant dollars. Although use of nominal values may be advantageous in certain cases, FAA analyses should continue the use of constant dollars as normal practice unless there is good reason to do otherwise. The following guidance presumes the use of constant dollars.

B. Period Between Analysis Date and Project Start Date

The selection of the yardstick of value measurement is arbitrary. The constant dollars of one year are as good as the constant dollars of any other year as far as the economics of the analysis goes. However, for practical considerations it is recommended that the constant dollars of the year of the analysis be selected as the unit of measurement. This procedure is a natural approach because it permits benefits and costs to be valued at their current prices. Moreover, it avoids the need to transform current prices into past or future year dollars and, with respect to future years, the need to forecast inflation. Note that this recommendation is not a hard and fast rule and should not be followed when other circumstances so indicate.

C. Inflation During Project Life

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[13] "OMB Circular A-94" (Revised--October 29, 1992) p. 8. The previous version of Circular A-94 (March 27, 1972) p. 3, had required that all analyses be conducted in constant dollars.

During the projected life of the proposed investment or regulation, changes in the general level of prices should not be allowed to impact the analysis. Benefits and costs are real quantities; they consist of the goods and services provided by a project and the resources consumed in providing them. Dollars enter the analysis only as the yardstick of value. To allow the unit of measurement to vary would assign different valuation to the same benefits or costs depending on the variation in the unit of measurement over the project's lifetime.[14] With the typical investment or regulation during times of increasing prices, large costs occurring early in the project's life would be assigned less value than benefits stretching out over the years. This could lead to projects being undertaken which are not worthwhile because inflation had been allowed to increase benefit values relative to cost values. To avoid such distortions, all benefits and costs associated with an investment or regulation must be measured in the constant dollars of a particular year--preferably the year of the analysis for reasons noted in Section IV. B. of this chapter.

There is an important qualification (not exception) to the general rule of expressing all quantities in the constant dollars of a particular year. Quantities that increase or decrease in value more or less than the general price level should have their values adjusted by the difference between changes in their value and the general price level. This must be done to reflect that their real values relative to the real values of other goods and services have changed apart from any changes in the general level of prices.

Adjustment for real price changes requires that the difference between forecast general price level changes and prices of the items in question be computed. This may be accomplished by taking the ratio of the specific item price index to the GDP Deflator (or GDP Chain-Type Price Index). The resultant index will show how much the specific item is forecast to increase or decrease in price once the impact of overall price level changes is removed. The resultant index may then be multiplied by the constant dollar estimate of the item in question in each year to adjust it for real changes in value. This procedure is demonstrated by equations (7-1) and (7-2):

$$RI_t = \frac{SPI_t}{GDPI_t} \qquad (7\text{-}1)$$

$$XA_t = XO_t\,(RI_t) \qquad (7\text{-}2)$$

where: SPI_t = specific item price index in year t,

[14] This statement assumes use of a real discount rate such as the OMB specified 7 percent rate. It would not hold if a nominal discount rate were used because the inflation premium built into the nominal rate should remove, at least approximately, the impacts of inflation.

$GDPI_t$ = implicit GDP deflator in year t,
RI_t = resultant index in year t,
XO_t = unadjusted real value, and
XA_t = real value adjusted for relative real price changes.

In practice, another procedure is often used. If a particular item is known to be changing in real value at an approximately constant rate, its value may be projected by equation (7-3):

$$XA_t = XO_t \ (l + f)^m \tag{7-3}$$

where: m = the number of years between year t and the year in which the constant dollars of measurement are stated, and
f = the annual rate of real relative price change.

This adjustment can be combined with the discounting procedure developed in Chapter 5 and defined in equation (5-6). Combination is possible because two ratios are being applied similarly to the same benefit or cost figure. This is indicated in equation (7-4):

$$NPV = \sum_{t=o}^{k} \frac{(B-C)'}{(1+r)^t} + \sum_{t=0}^{k} X_t \left[\frac{1+f}{1+r}\right]^t \tag{7-4}$$

where: X_t = the quantity in year t being adjusted expressed in constant dollars of the year of initial project implementation,
$(B\text{-}C)_t'$ = all benefits and costs other than those contained in X_t,
r = the discount rate, and
k = the total number of periods in the evaluation period of the project or regulation.

A typical situation where real cost changes must be considered arises with respect to replacement projects. One advantage of the proposed new system over the old often is that it replaces an old technology with a new one. In cases where the real cost of the old technology is projected to increase with time, the absolute amount of the new system's advantage continually increases. While it is proper to include such an ever increasing advantage in an evaluation, the burden of establishing an appropriate rate of increase rests squarely on the shoulders of the analyst. Conclusions which result solely from assuming large real cost increases in the existing system which are not thoroughly justified are not convincing and are easily contested.