INFLATION AND ESCALATION BEST PRACTICES FOR COST ANALYSIS

ANALYST HANDBOOK

OFFICE OF THE SECRETARY OF DEFENSE

COST ASSESSMENT
AND PROGRAM EVALUATION

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Contents

1. Introduction

Increasing costs for defense acquisitions has long concerned officials in the Department of Defense.[1] In 1958, Secretary of Defense Neil H. McElroy observed cost increases emanating from three interrelated sources: fewer production orders within programs; large technological advances between programs; and wage and price increases of defense resources. But what proportion of that cost change is attributable to fewer production units bought and thus less productivity achieved? What proportion is attributable to increasing the capabilities of submarines from diesel to nuclear power, and the subsequent addition of ballistic missile capabilities? What proportion of the cost change remains un-attributable to the previous sources?

When defense analysts attempt to estimate the cost of systems, they are chiefly concerned with understanding the cost effects of defense decisions. These decisions come in two broad forms: what to buy and how much to buy. To properly estimate the cost of a new system, the analyst needs to understand the relationships among historical costs, technical characteristics, and quantity orders. In order to derive realistic relationships, and ultimately estimate the final cost, the analyst will have to account for the effects of persistent underlying cost changes that occur regardless of individual programmatic decisions, specifically inflation and escalation. This handbook will help analysts use price indices to both estimate realistic program costs as well as to present those costs in a way that facilitates decision-making.

This handbook supersedes the prior OSD CAPE publications, "Inflation and Escalation Best Practices for Cost Analysis" (April 2016) and "Inflation and Escalation Best Practices for Cost Analysis: Analyst Handbook" (January 2017).

[1] Other observers have made note as well. In *An Inquiry into the Nature and Causes of the Wealth of Nations* (1776), Adam Smith wrote: "… the art of war, too, has gradually grown up to be a very intricate and complicated science…. Both [military] arms and their ammunition are become more expensive. A musket is a more expensive machine than a javelin or a bow and arrows; a cannon or a mortar than a balista or a catapulta. The powder which is spent in a modern review is lost irrecoverably, and occasions a very considerable expense. The javelins and arrows which were thrown or shot in an ancient one, could easily be picked up again, and were besides of very little value. The cannon and the mortar are not only much dearer, but much heavier machines than the balista or catapulta, and require a greater expense, not only to prepare them for the field, but to carry them to it."

A. Background and purpose

A weapon system's cost depends in part on price changes in the broader acquisition process and external market economy. Well-researched forecasts of price changes help the Department of Defense (DoD) make sound acquisition trade-offs and adequately budget for the development, procurement, and sustainment of defense systems.

To illustrate, suppose DoD plans to procure a certain aircraft five years in the future. If an analyst assumes that the current aircraft price of $100M will grow at the forecasted economy-wide inflation rate of about 2 percent, DoD would budget $110M per aircraft for the procurement. But if there is reason to believe that prices for the aircraft industry will instead escalate at 3 percent annually, the unit cost[2] would grow from $110M to $116M. This unanticipated growth above budget could force DoD to buy fewer aircraft, accept unattractive compromises to schedule or quality, or to reprogram funding. Additionally, the average unit cost of the aircraft in inflation-adjusted constant-year dollars, for the year of procurement—the metric that Congress would track to assess DoD's management of the program—would also be higher than planned, $105M versus the expected $100M.

The above example shows the importance of considering price change in cost estimates, and introduces two types of price change: ***inflation***, which is an economy-wide increase in the average price level, and ***escalation***, which refers to changes in the prices of specific goods and services (including inflation). The difference between inflation and escalation raises several significant issues for cost analysis. In addition to understanding concepts and terms, analysts must be able to determine the most appropriate index for a given analysis. Many of the indices DoD publishes represent inflation only, so analysts may need to perform additional research to find appropriate escalation indices.

Section 3221 (formerly Section 2334) of Title 10, United States Code requires the Director, Cost Assessment and Program Evaluation (DCAPE) to "periodically assess and update the cost indexes used by the Department to ensure that such indexes have a sound basis and meet the Department's needs for realistic cost estimation." DCAPE published this handbook to help analysts meet these objectives. Developed in collaboration with cost estimators and economists in the Office of the Secretary of Defense (OSD) and the Military Services, the handbook provides best-practice guidelines for incorporating price change into cost analysis, and teaches analysts how to implement them. The escalation best practices are:

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[2] Price is often defined as the sum of production costs and profit. This handbook will use the term cost for DoD purchases because profit is generally negotiated as a percent of cost for major systems.

- Adopt consistent terminology.
- Use realistic escalation rates to estimate costs in Then-Year dollars.
- Select long-term assumptions about fuel prices, military pay, and other rates to balance the realism and stability of estimates.
- Normalize inputs appropriately for use in cost estimating calculations.
- For external reports that support budgeting and decision-making, present cost estimates in Then-Year dollars (which represent the most complete and accurate forecast of costs) and Constant-Year dollars when comparisons are required or expected.
- Document and label all indices used in an analysis.

Analysts are expected to use this handbook's terminology and procedures appropriately. Cost estimates should incorporate the escalation rates that best forecast funding requirements for the system being estimated, taking specific markets into account. Cost analysts (and the organizations publishing estimates) are responsible for determining which escalation assumptions are appropriate and where they are applicable; for conducting analyses necessary to forecast escalation affecting system costs; and for developing the rationale for their approach. The cost community should foster the data and methods necessary to measure escalation affecting weapons systems, and encourage analysts to assess all escalation rates affecting their analyses.

B. Scope

This handbook focuses on the differences between inflation and escalation and their importance to cost analysis, and suggests methods of approaching cost problems in light of the various types of price change. This handbook is intended for the entire DoD cost analysis community: analysts in OSD, the Military Departments, the Office of the Chairman of the Joint Chiefs of Staff and the Joint Staff, the Combatant Commands, the Office of the Inspector General of the Department of Defense, the Defense Agencies, the DoD Field Activities, support contractors, and all other organizational entities within the DoD. The methods apply to costing all phases of a program's lifecycle and to all appropriation titles.

This document is organized by best practices. It starts with terminology and a framework for assessing escalation. Next, it provides advice for diagnosing input types and selecting desired output types for particular applications, such as Cost Estimating Relationships (CERs) and cost improvement curves. It also includes information on how to choose appropriate indices, as well as step-by-step instructions to complete basic and advanced calculations. Finally, it discusses common errors and sources of biases in inflation and escalation assumptions, and best practices for documentation.

C. Changes since the previous version

The previous versions of this handbook first introduced and justified the major terminology change of distinguishing inflation and escalation, as well as the definitions of real price change and constant price. Implementation of these concepts has been slow because their existence greatly increased the complexity of this subject, which expanded from two to five dollar types (then-year obligations, then-year expenditures, constant-year obligations, constant-year expenditures, and constant price) and from one to three types of price change (inflation, escalation, and real price change).

This version of the handbook expands on previous definitions and adds step-by-step instructions, aiming to increase the practical application of escalation and real price change across the cost estimating community. Some of the most significant changes for this version include:

- Added detail on the difference between obligations and expenditures (for both then-year dollars and constant-year dollars) and the definition of outlay profiles (Chapter 2)
- Expanded definition of constant price to differentiate between normalized data and modeling for forecasts (Chapter 2)
- Expanded definition of real price change to include quality and quantity changes, explanation of effects on cost models when difficult to isolate (Chapter 2)
- Added step-by-step instructions for basic calculations (Chapter 7)
- Added quick-reference flow charts (Chapters 4-6)
- Cancelled "base year dollars" as a formally recognized dollar type for cost estimates (Chapter 2)
- Differentiated between discrete modeling techniques for real price change versus modeling via indices (Chapter 3)
- Added instructions for how to assume a midpoint for multi-year inputs, or how to manually allocate multi-year inputs to single years (Chapter 7)
- Added concept of "transaction year" as distinct from "base year" (Chapter 2)
- Added instructions for making a custom index (Chapter 7)
- Added instructions for changing the base year of an index (Chapter 7)
- Added chapter discussing uncertainty: how to avoid mistakes and understand bias (Chapter 8)

This version of the handbook is considerably longer than its predecessor, and some readers may be discouraged when they see the page count. This handbook serves as a desktop reference, rather than as a set of instructions to be consumed in one sitting.

To digest this document in pieces, first read the definitions and framework description in Chapters 2 and 3, which provide the necessary theoretical basis for concepts associated with escalation. Then, from Chapters 4-6, use the following figures to make estimating decisions, referring to the surrounding text when you need to understand more of the theory behind the figures' recommendations:

- Figure 4-2: Flowchart to identify unknown input types ("Carrot Chart")
- Figure 5-1: Applications of various output types
- Figure 5-2: Output types at various points in cost estimating process ("Pitchfork Chart")
- Figure 6-1: Flowchart for selecting an index ("Nunchuck Chart")

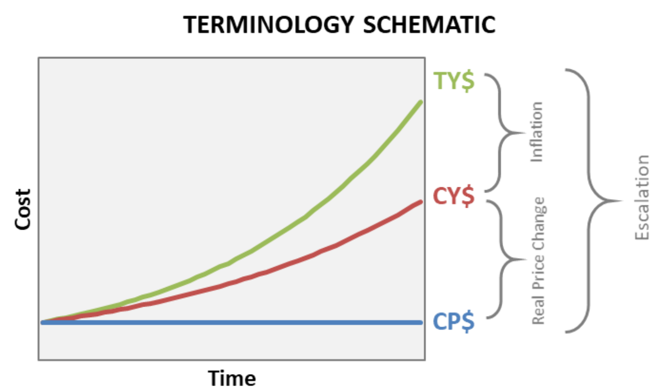
Finally, apply the concepts from Chapters 4-6 when following the step-by-step instructions in Chapter 7, skim Chapter 8 to familiarize yourself with the information for future reference, and adhere to the documentation best practices in Chapter 9.

2. Terminology

This chapter will introduce the best-practice terminology used throughout this handbook. Chapter 3 supplements these definitions with a flexible framework that will help you apply them in real-world cost estimates. Appendix A contains a glossary with abbreviated definitions.

Figure 2-1 shows the primary terms covered in this chapter. Each line shows a type of dollars: then-year, constant-year, and constant price. The differences in price change content are labeled on the right: escalation, inflation, and real price change. Note that this graphic is a simplification to demonstrate the basic terms, and it does not cover all of the concepts presented in this handbook.[3]

Figure 2-1. Basic terminology.
This graph assumes positive real price change, which may not apply to all cost elements.



A. Inflation

Inflation refers to a rise in the general price level over time, which is an economy-wide average over all goods and services transacted. Inflation represents a decrease in the value of money (i.e., the dollar), due to an increase in the supply of money and credit relative to available goods, resulting in a rise in the general price level.[4] Since money is on one side of every market transaction and is the unit of account against which the values of all other goods are measured, inflation affects all prices in the same proportion.

[3] Some concepts that are not included in this graphic include the effect of outlay profiles (which would increase the y-intercept of the TY$ and CY$ lines and change their overall shapes slightly) and the interactive effect of inflation and real price change (which is an area of overlap between those labels on the right side).

[4] The opposite trend of a decrease in the general price level is called deflation. Deflation is comparatively rare over a sustained period of time.

A rise in the general price level means that a given amount of money buys fewer goods and services.

Key to the definition of inflation is that it measures the *economy-wide* change in price as opposed to the change in price of any specific good or service.[5] The inflation index used in Federal budgeting is the Gross Domestic Product Chain-Type Price Index,[6] known more commonly as the GDP Price Index and abbreviated in this handbook as the GDPPI. The Bureau of Economic Analysis (BEA) of the Department of Commerce develops the index based on value-added prices of all final goods and services (sometimes referred to as a "market basket") produced on US soil. It includes investment goods, consumption goods, services, and products exported overseas. The BEA also calculates the GDP Implicit Price Deflator, which is extremely close to the GDPPI but differs in its technical details.

B. Real price change

While inflation affects all prices in the same proportion, prices for specific goods and services may change at different rates due to real price change (sometimes abbreviated RPC). Positive real price change indicates that the item has become more expensive relative to an economy-wide basket of goods and services, whereas negative real price change indicates it has become relatively less expensive. The label "real" in real price change refers to the fact that it is measured in inflation-adjusted dollars, also known as "real dollars."

The following examples of real price change are specific to particular markets, producers, consumers, goods, and services, thus distinguishing real price change from economy-wide inflation. For any good or service, real price change may include a combination of these and other forces depending on the context of the good or service within the economy over time.

- Market shifts
- Changes in the supplies of specific materials
- Changes to cost of doing business (e.g., overhead rates), for either contractors or the government
- Economies or diseconomies of scale
- Changes in the mix of the workforce, such as labor categories or skill levels
- Changes to inputs to production
- Rate effects and learning effects
- Technological change, such as increased automation of a production process

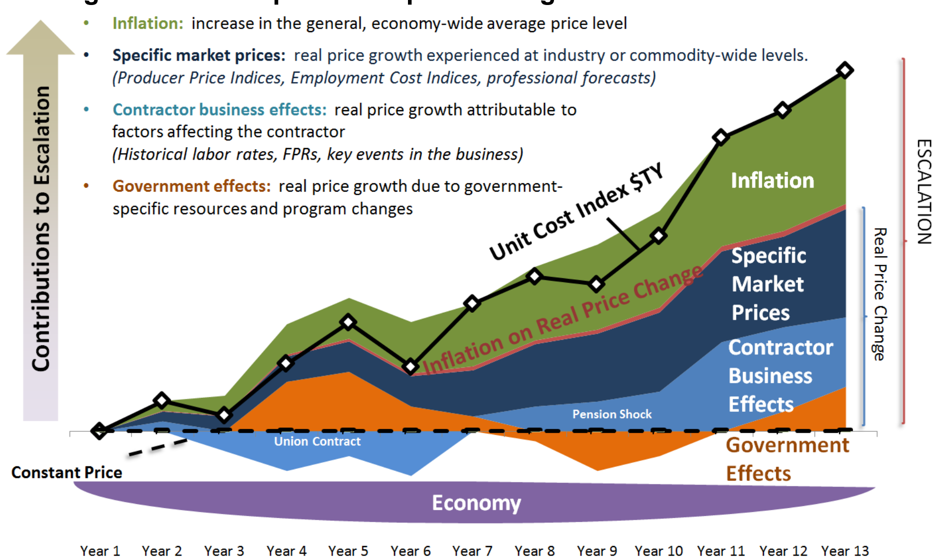
[5] The Office of Management and Budget (OMB) Circular A-94 defines inflation as "the proportionate rate of change in the general price level, as opposed to the proportionate increase in a specific price."

[6] OMB Historical Tables and OMB A-94.

The inclusion of several of the items on the list above may surprise some DoD cost estimators, particularly rate effects, learning effects, and overhead rates. These types of real price change are often major research topics in the creation of cost estimates, but are not generally modeled in the same way as inflation. However, just because a cost driver contributes to the real (i.e., inflation-adjusted) change in price of a weapon system does not mean it must be modeled as a compounding annual rate, as with inflation. Chapter 3 discusses the option to model certain types of real price change discretely when possible, as opposed to using indices to capture them in broader strokes.

Chapter 3 also provides guidance on analyzing and categorizing real price change at various levels of detail, as appropriate for any given estimate or portion thereof. For example, Figure 2-2 below breaks down real price change for a notional program into market-related prices (e.g., raw materials, labor), contractor business effects (e.g., change in business base, change in pension plans, geographic relocation, implementation of process improvements), and government effects (e.g., government-driven schedule changes, quantity changes).

Figure 2-2. Example of real price change and inflation in observed data.



Understanding historical real price change in detail will help you understand the cost drivers affecting your estimate, and may inform forecasted costs as well. It may be appropriate to assume that the forces driving historical real price change will apply in the future, even if the forecasted rate of change is different from the historical rate. If you are unable to find an index that forecasts future real price change for a commodity of interest, you should consider applying observed historical rates rather than omitting real price change altogether. A failure to account for real price change would underestimate costs if the rate of change is positive, or overestimate costs if it is negative.

To measure the full extent of real price change present in historical data, normalize for inflation and then measure the remaining variation in costs over time as shown in Figure 2-3. You may also be able to decompose the total observed rate of real price change into discrete forces, as discussed in Chapter 3, if sufficient information is available. Analyzing real price change at this granular level of detail may help you communicate specific cost drivers and risks to decision makers.

C. Escalation

Escalation is the combined effect of inflation and real price change, as defined in the previous two sections. Some other terms that may refer to escalation include price change, market price change, specific price change or growth, and price escalation. These terms are somewhat ambiguous and may mean different things to different people. Always confirm content and definitions when discussing escalation with others because these definitions are often misunderstood or misapplied.

Escalation may be positive, negative, or zero; since inflation is usually positive in a growing economy, the direction of escalation depends primarily on the magnitude and sign of real price change (see Appendix C for graphics). Escalation may also be equal to inflation in two cases: the market basket may be so broad that it approximates the entire economy (which, by definition, experiences inflation only), or the market basket experiences no real price change relative to the economy as a whole.

A cost analyst may consider how the economy affects escalation for weapon systems. For example, changes in the unemployment rate are likely to affect the rate of change of defense workers' wages and salaries. Also, exchange rates can have relatively volatile effects on prices in foreign-based supply chains. For example, if the currency of a foreign supplier were depreciating, making the dollar-value of the materials cheaper, your analysis should consider how this factor affecting prices will behave in the future. You are not expected to make detailed forecasts of unemployment, labor productivity, exchange rates, or other economic factors, but you are encouraged to think about how this information can help explain past escalation or predict future unit cost changes.

Inflation and real price change (RPC) are multiplicative rates, which yields the following equation for escalation. Express the rates of change as decimals for use as multipliers: for example, 1.02 represents a +2% change over the time period (usually comparing Year X to Year X+1), 0.98 represents a -2% change, and 1.00 represents no change.

(Rates as Decimals): **Escalation = Inflation × RPC**

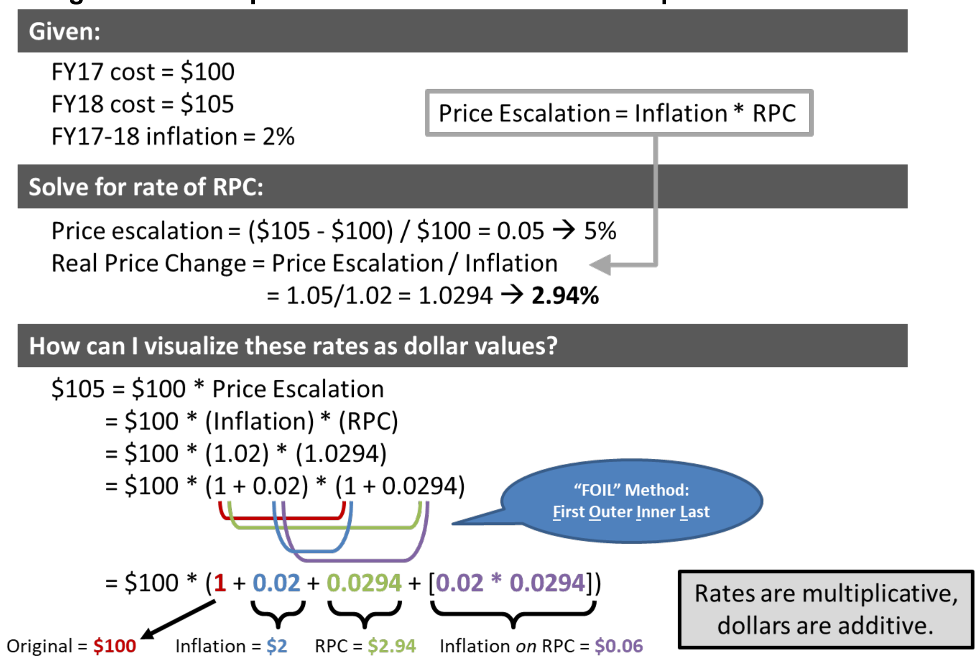
The multiplicative relationship shown above applies only to the decimal form of the rates—when shown in terms of additive dollars instead, an interaction term appears in the equation:

(Dollars): Escalation = Inflation + RPC + Inflation on RPC

For example, if a cost element experiences inflation at 2.00% and real price change at 2.00%, the escalation rate will be 4.04%. The additional 0.04% is the interaction term, or inflation *on* the real price change.

The example in Figure 2-3 shows the origination of this interaction term. Only calculate this term separately when attempting to estimate or display escalation as the sum of its parts. For example, you may apply real price change as a discrete rate separately from inflation for a given cost element, and want to show the independent dollar impact of each force on the total cost.

Figure 2-3. Multiplicative and additive relationships of conversions.

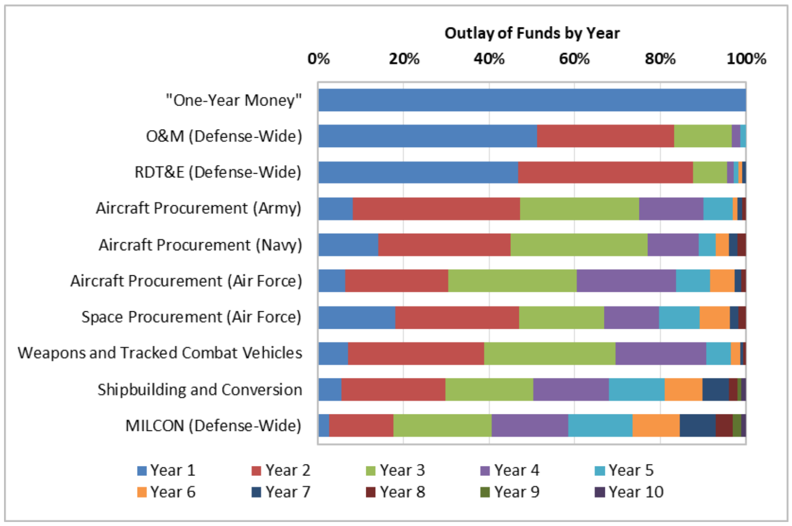


D. Then-Year dollars (TY$) and outlay profiles

Then-Year dollars, often called "nominal dollars" beyond the DoD, are the most easily understood of the dollar types discussed in this handbook: they have real-world significance, as in the dollars you would actually use to purchase a good or service at the time of the transaction. Such dollars have not been normalized, and reflect the purchasing power at the time the transaction is recorded. There are two types of TY$ in the federal environment—obligations and expenditures—which represent different types of transactions.

Obligations ("TY$ obs") are TY$ that often represent budgeted values, and are recorded prior to the disbursement of funds from the US Treasury—even by as many as 10 years depending on the appropriation. The timing pattern in which funds are expended is an ***outlay profile***, usually expressed as a percentage of funds expended per year (see Figure 2-4 for examples). By the time funds actually leave the Treasury to pay for a budgeted good or service, the dollar value of the good or service may have changed relative to its dollar value at the time of obligation (e.g., increased due to escalation). Obligations include an adjustment to account for this anticipated change in dollar value.[7] Since most prices increase over time, this adjustment generally increases the amount in the obligation year to cover the actual funding required to be paid in the expenditure year(s). Note that some appropriations (e.g., military or civilian pay, fuel) are for "one-year money," meaning that they are fully expended in the year of obligation or have an outlay profile of 100 percent in the first year; in such cases, obligations are equal to expenditures.

Figure 2-4. Outlay profiles for select appropriations, from FY 2020 President's Budget Green Book.



Expenditures ("TY$ exp") are another type of TY$, and represent dollars at the time they leave the US Treasury to pay a bill. Unlike obligations, expenditures do not experience a time delay and therefore do not need outlay profiles to adjust for anticipated changes in value. Expenditures for all appropriations function as though they have an outlay profile of 100 percent in the first year.

The difference between TY$ exp and TY$ obs becomes important when selecting indices for calculations, as described in Chapter 6. For calculations involving TY$ obs, you must use ***weighted indices*** that account for the aggregate change in buying power over the course of the appropriation's outlay period. For calculations involving TY$ exp, you must use ***raw indices***, which do not include an outlay profile. Raw and weighted indices may measure either the full rate of escalation or inflation only. See Chapter 7

[7] See Chapter 6 section C for information on weighted indices, which apply this adjustment using outlay profiles, and Chapter 7 section E for instructions on making weighted indices.

section E for an example showing how to create a weighted index using a raw index and an outlay profile.

> The next sections describe two other categories of dollars, each of which is the result of ***normalization***. Keep in mind as you proceed that Then-Year dollars are NOT normalized relative to a point in time that differs from when they were or will be recorded – they have meaning in the real world and measure actual transfers of funds, whereas time-normalized costs have been adjusted for the purposes of estimating, comparing, or reporting.

E. Constant-Year dollars (CY$)

Constant-Year dollars, often called "real dollars" beyond the DoD, have been normalized for inflation using an economy-wide index such as the GDPPI. A cost normalized to CY$ is a counterfactual, measuring prices relative to a selected base year as though inflation were zero. Costs in CY$ are "counterfactual" because they do not exist in the real world—you cannot go to a store in 2020 and pay for goods using dollars at their value in 2018's economy. However, CY$ are useful in cost reporting and comparisons because they remove a confounding variable (i.e., the changing value of money) from the subject of interest (e.g., weapon system costs).

This handbook recognizes, for the first time in DoD guidance, the existence of two different CY$ types: CY$ obligations (CY$ obs) and CY$ expenditures (CY$ exp). The removal of inflation from TY$ obs yields CY$ obs, and the removal of inflation from TY$ exp yields CY$ exp. Although both CY$ types include real price change, CY$ obs also include the effect of the outlay profile on that real price change, while no outlay profile is present in CY$ exp. There are very limited circumstances under which CY$ exp are appropriate for use in cost estimating, as discussed in Chapter 5 section C; for almost all cost estimating tasks, you should calculate or use CY$ obs instead of CY$ exp.

Costs marked as CY$ should include the year against which costs were normalized (the "base year," see section H). Nomenclature is flexible as long as it is clear that it is constant-year dollars, and consistent within a given project; for example, a cost in FY 2025 normalized to CY$ with a base year of FY 2020 could be represented as "CY20$" or "CY$, BY20" or "CY2020$," etc. Notice that none of these notations identify the costs as representing a transaction in FY 2025—although this is an important piece of information—only the base year (FY 2020) against which the costs are normalized. See section H for more information about referencing transaction years.

The next section on constant price also presents a counterfactual cost. The difference between these types of normalized dollars is the index used to produce them; by definition, a CY$ must be created using an index that measures only economy-wide inflation. A constant price is the result of normalizing with an index that measures escalation.

F. Constant price (CP$)

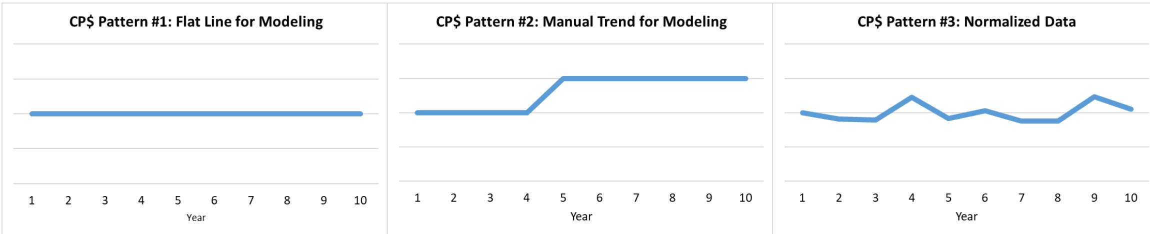
The term ***constant price*** refers to costs that, when expressed relative to a base year, do not include the effect of escalation (i.e., they include neither inflation nor real price change). This definition is somewhat idealized, as it is not always possible to remove all real price change (the exact value of which may not be known) when normalizing historical costs to CP$. Do not let this ambiguity intimidate you, as it provides some flexibility in how you use CP$ as a modeling tool—the estimating framework provided in Chapter 3 will help you work within these flexible boundaries of the definition of CP$.

Costs marked as CP$ should include the year against which costs were normalized (the "base year," see section H). Nomenclature is flexible as long as it is clear that it is constant price, and consistent within a given project; for example, a cost in FY 2025 normalized to CP$ with a base year of FY 2020 could be represented as "CP20$" or "CP$, BY20" or "CP2020$," etc. Notice that none of these notations identify the costs as representing a transaction in FY 2025—although this is an important piece of information—only the year (FY 2020) against which the costs are normalized. See section H for more information about referencing transaction years.

Unlike TY$ obs and CY$ obs, which are frequently used to express results to external customers of DoD cost estimates, CP$ should only be used internally as a modeling technique or to understand historical trends. You should not generally present CP$ in external reports unless doing so is required to explain the methodology used to reach your reported results in TY$ obs or CY$ obs, for reasons described in detail in Chapter 8 section C.

Constant prices are often visualized in training material as a flat line, but costs do not have to be equal in all years to represent CP$. In fact, CP$ may follow three general patterns when graphed over time, as shown in the notional examples in Figure 2-5 below. The first two patterns are used for modeling future costs (where the second reflects the impact of applying discrete cost estimating adjustments such as changes in quantity), while the third is the result of normalizing data with an escalation index.

Figure 2-5. Constant Price (CP$) cost profile patterns.



- Pattern #1: value is equal for all years
- Pattern #2: value changes over time due to an identifiable trend[8]
- Pattern #3: value changes over time due to unknown or complex forces, either in historical or forecasted data[9]

For example, say a program office awards a contract for phone service at a total price of $1.0M for the first year, Fiscal Year 2020 (FY20). The program office wants you to estimate the total cost for phone service for a ten-year period.

Your first step might be to model the costs using CP$ Pattern #1, with a value of $1.0M for each year. This model would apply the input data as a CP20$ profile, in which costs are equal (at the FY20 price) for all years. Using the most literal interpretation of the words "constant price," this pattern uses a completely static value over time.[10] If the service contract is expected to be a fixed-price contract at $1.0M per year for the full ten-year period, this CP20$ profile would be equal to the TY$ estimate. However, if you expect the provider to raise its service rates over time, you could convert the CP20$ profile to TY$ using a table of future rates from the provider, or a generic escalation index for telecommunications services from a publicly available source.

Alternatively, perhaps the program office tells you that it is going to increase its number of phone lines by 10 percent in the fifth year because of an expected increase in staffing. You might then create a CP20$ profile like the one shown in CP$ Pattern #2, with a jump in price due to a known change in the quantity of the item (here, the number

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[8] Chapter 3 will help you determine what types of trends are considered "identifiable," generally anything you are modeling discretely in your estimate. Some examples include changes in number of items estimated, change in usage (e.g., flying hours, miles), learning effects, etc.

[9] Note that this pattern may also be observed when data is normalized to CY$. The distinguishing feature between CY$ and CP$ is not the "shape" of the resulting data, but the type of index used to produce the normalized cost profile: normalization via inflation indices produces CY$, and normalization via escalation indices produces CP$.

[10] Prior to the previous version of this handbook (2017), the "flat line" representation of costs was referred to as Constant Year or Base Year dollars. In 2015, the DoD recognized that "Constant Year" dollars refer specifically to inflation-normalized costs ("real dollars" in classic economics terms), which may *not* be a flat line. For any commodities that experience escalation at a different rate than inflation, there is a divergence between what would be a flat line (CP$) and inflation-adjusted costs (CY$).

of phone lines). As long as the increase does not include *price* changes (such as service rates) relative to FY20, the line represents CP20$ even though it is not entirely flat. To convert this CP20$ profile to TY$, you would apply price changes for each year using provider-specific rates or a more generic escalation index as described for Pattern #1 above.

Finally, you might decide to research historical data for the program office's communications services for comparison, and obtain records of similar contract expenditures (TY$) for the past 10 years. You identify a relevant escalation index for telecommunications services (from the past provider or from a publicly available source) to normalize these historical costs to CP20$. The normalized costs might look like CP$ Pattern #3, in which there is inconsistent variation from year to year. The remaining variation is a result of factors not represented in the escalation index used for normalization (i.e., variables you are unable to normalize for), such as unknown changes in the quantity or quality of services during the historical period. If you used a generic telecommunications escalation index to normalize the costs, some of the variation may also be the result of provider-unique pricing changes that differed from those experienced by the broader telecommunications sector of the economy (as described by the index applied).

This example raises the question, "how do I know which index to use to de-escalate TY$ to CP$?" There is no easy answer in most cases, as the choice of index will depend on what you are estimating and how you are accounting for interrelated forces. Publicly available indices are useful tools for characterizing some causes of real price change, but there will be many other cost drivers that you could not—and would not want to—characterize with an escalation index alone. Chapter 3 provides a conceptual framework for understanding how escalation and real price change relate to other cost drivers, and Chapter 6 discusses index content.

When you obtain a result like CP$ Pattern #3 for normalized data, you may want to further normalize the data depending on the trends you are trying to characterize (e.g., calculate cost per phone line to account for quantity changes, rather than using total contract cost alone). Economists who produce publicly available escalation indices often attempt to control for quantity and quality changes so that their indices represent pure price change; for example, an economist might track the price of a particular laptop over time, and manually adjust the index values to account for changes in the number of units purchased and any price-driving improvements in quality. For this reason, economists generally do not consider quantity and quality changes to be a type of real price change, contrary to this handbook.

The option of controlling for quantity and quality changes via indices as described above is often not available for DoD cost estimators, as we are unlikely to find publicly available indices that perfectly describe the quantity and quality changes of the weapon systems or subsystems we are estimating. In fact, a primary feature of cost estimating is modeling those effects discretely through techniques such as learning curves and cost estimating relationships, which are described in other DoD cost estimating guidance. This handbook puts those techniques into context relative to escalation and inflation so you will know when and how to apply them, particularly in Chapters 3 and 5.

To review the concept of constant price, the following example shows how all three patterns of CP$ could come into play in a single cost element. Adding onto the previous example, say your program office has asked you to estimate the travel budget for five years, FY21-25. You obtain historical expenditures (TY$) for travel per employee, and locate an escalation index for generic travel prices from a publicly available source. You use this index to normalize the historical per-person travel costs to CP20$, resulting in costs that follow CP$ Pattern #3 from Figure 2-5. You notice that the CP20$ costs have been relatively consistent for the past five years, with an average of $10,000 per year. You use $10,000 as a flat-line CP20$ input (Pattern #1) to begin forecasting the costs for FY21-25. You then discover that upcoming program changes will require people to travel overseas more frequently starting in FY23; you decide to modify your flat-line profile of $10,000 per year to include a 30% increase for FY23 and beyond (Pattern #2) to account for your assessment of the cost increase associated with international travel. Finally, you use an escalation index for travel prices (perhaps the same one you used for your initial normalization, if you think it is representative of future prices) to convert your CP20$ profile to TY$.

G. Cancellation of "base year dollars (BY$)" as a dollar type

As of the publication of this handbook, "base year dollars (BY$)" are no longer considered a valid dollar type. Cost estimators often use this outdated term to refer to either CY$ or CP$, but do not provide sufficient information (i.e., the index used to produce the value) to determine which of the two it represents. By using the terms CY$ and CP$ instead, cost estimators can easily identify the type of index used to produce each value, and make appropriate decisions regarding their use.

Although no longer valid as a dollar type, the concept of a "base year" is still relevant to the concepts in this handbook, as described in the next section. In short, a base year is a point in time against which costs are measured, and may apply to CY$, CP$, and indices themselves.

H. Transaction year vs. base year

The conversions described in this handbook manipulate the relationship between costs and time in order to study, forecast, or control for time-correlated pricing effects. These manipulations can seem abstract, and it can be difficult to articulate what a given cost represents after normalization. To better keep track of costs, this version of the handbook introduces a new term ("transaction year") and more explicitly defines an older term ("base year") to better align with its use in the broader economics community.

Transaction year refers to the time at which an obligation is obligated or an expenditure is expended, depending on the type of data you're using. All costs, regardless of whether they represent TY$ from a primary source or have been normalized to CY$ or CP$, represent costs that occurred or will occur at this point in time.

When TY$ costs are normalized to either CY$ or CP$, they take on an additional characteristic of a ***base year*** that does not apply to TY$. While CY$ and CP$ retain their transaction year (i.e., the costs still represent that point in time), they are now measured relative to the base year of the index used to normalize them. In other words, they are restated in the dollar-units of the index base year—normalized for either inflation (CY$) or escalation (CP$), depending on the index type—but they still occur in the transaction year. For weapon system estimates supporting major decisions such as milestones, the year of the decision is often chosen as the "program base year" in order to have a consistent point of reference. The actual year selected does not impact the results, as demonstrated in Chapter 7 section F.[11]

A failure to keep track of the transaction year when dealing with normalized costs can lead to inaccurate calculations when converting dollar types. For example, normalizing a TY$ cost incurred in FY20 to CY18$ (such as to compare to another program baselined to CY18$) does not mean that the costs now occur in FY18; we are simply measuring the cost for FY20 (the transaction year) in terms of FY18 dollars (the base year). This distinction may seem like a minor issue of semantics, but can lead to errors in calculations and interpretation of results; Chapter 4 section D will explain the importance of this distinction when dealing with data representing a single year.

When you are ready to begin the conversion calculations described in Chapter 7 section A, you will need to specify a parameter called $Year_{in}$ to identify the first index value required. The transaction year will be $Year_{in}$ for TY$ inputs, and the base year will be $Year_{in}$ for CY$ and CP$ inputs.

I. Indices

An index is like a ruler that measures a given type of price change relative to a specified point in time. Most indices measure annual price change (e.g., calendar year, government fiscal year), though some measure changes by quarter or by month. The year

[11] You generally should not select a future year as a base year for your estimate, as the index values for future years are subject to change. Forecasted inflation and escalation are rarely perfectly accurate, so using a future base year will subject the entire estimate to that forecast error. Even using a past year as the base year can induce the same error if the full outlay period has not been completed, as any weighted indices used may include future years' forecasted rates.

against which the index values for all other years are measured is called the "base year" of the index. You may use an index with a base year that matches your estimate's base year, but it is not necessary to do so (see Chapter 7 section F for more information on base years as they relate to indices). There is also considerably more information on indices in Chapter 6. Note that some sources refer to indices as "deflators," but that name does not necessarily mean that the index measures inflation only.

You may encounter indices that require manipulation before you can use them in your estimate. For example, some sources of labor escalation rates display salary by year instead of as a multiplier relative to the base year. To convert such an index for use in your estimate, select a base year and divide each year's value by the base year's value (this will create a series of multipliers with 1.0000 in the base year). Other sources may display year-over-year percentage changes, in which case you should follow the instructions for building indices as shown in Chapter 7 section D.

J. Terminology confusion and controversy

The terms "escalation" and "inflation" are often used interchangeably in casual conversation, but these terms have distinct definitions and confusing them can lead to misunderstandings. Figure 2-6 presents some examples of correct and incorrect terminology in selected cost scenarios; the preferred terms, as used in this handbook, are in **<u>underlined bold</u>**.

Figure 2-6. Examples of correct and incorrect terminology

What Happened	Examples of Correct Terminology	Incorrect Terminology
The price of medical procedures increased 3%	• Medical escalation • **<u>Escalation</u>** • Price change • Specific price change	• Inflation • Medical Inflation
The general price level in the U.S. increased 1.7%	• **<u>Inflation</u>** • General price inflation	• Escalation • Specific price change
Government civilian pay increased 1.5%	• Pay raise • **<u>Escalation</u>** • Wage growth	• Inflation • Pay inflation • De-escalation
Excluding inflation, the price of material increased 3%	• **<u>Real price change</u>**	• Material inflation • Material escalation • Escalation • Cost growth above inflation

The terms presented in this handbook, including the incorrect ones above, have evolved over time. Prior to 2015, there was no explicit differentiation between inflation and escalation in DoD cost policy, and the application of real price change was not a standard practice. There was some recognition of price-changing forces that differed from inflation, leading to the creation of the term "cost growth above inflation" to ensure that all costs were captured; this term should no longer be used, as it has grown in scope to include forces other than real price change. The terminology as presented here was developed in 2015, and published in the previous versions of this handbook.

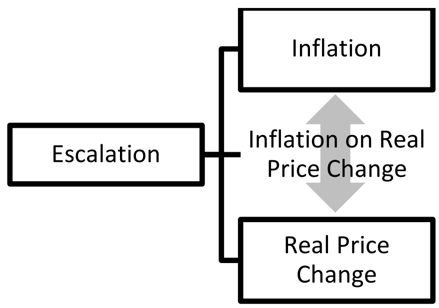
Some of the terminology used here has been tailored for use by the cost estimating community, which may make comparisons to general economics materials difficult. For example, the difference between obligations and expenditures is unique to Federal budgeting practices, economists refer to TY$ as "nominal dollars" and to CY$ as "real dollars," and the concept of CP$ is unique to cost estimating. Although the economics community provides the tools (indices) required to normalize historical data for escalation, CP$ do not have a clear use case outside of a cost estimate (such as to use in a cost estimating relationship or to create an average cost factor across multiple years). The application of constant prices as the basis of forecasts is also a cost estimating-specific activity—the counterfactual of "prices remain constant in perpetuity" would not provide useful insights to an economist, but it is a useful modeling tool for cost estimators who apply forecasted escalation in later steps.

Because some of the terms presented in this handbook are unique to the cost estimating community, you may find information in other sources that appears to contradict this guidance. Please keep in mind that it will take some time for these terms and methodologies to be accepted and implemented across the cost estimating community, and that some sources that are not designed for cost estimators may not use these terms in the same way or with the same degree of differentiation and precision as required for accurate cost analysis.

3. Framework for Analyzing Escalation

All goods and services produced in the US economy are subject to the same overall rate of inflation, but the causes of real price change (and therefore escalation overall) may vary from one commodity to another. Cost estimates generally capture multiple commodities (e.g., types of materials, labor categories, etc.), meaning that different cost elements may be subject to different rates of escalation. Figure 3-1 provides a basic framework for understanding the relationships among these terms from Chapter 2, and notes the interactive term that accounts for the inflation that occurs on top of any cost increase or decrease due to real price change.

Figure 3-1. Simple escalation framework categories.



Ideally, cost analysts will be able to expand this simple framework by breaking out real price change into more detail. Identifying the forces that cause real price change within an estimate or portion thereof will help you understand key cost drivers, and select forecasts for future price change.

This chapter contains a framework that provides categories of real price change for you to consider as you complete your estimate. The framework was developed from a cost estimator's perspective, and relates real price change to specific analytical techniques that DoD cost estimators apply. Feel free to customize the framework categories as needed given the information you have for your estimates.

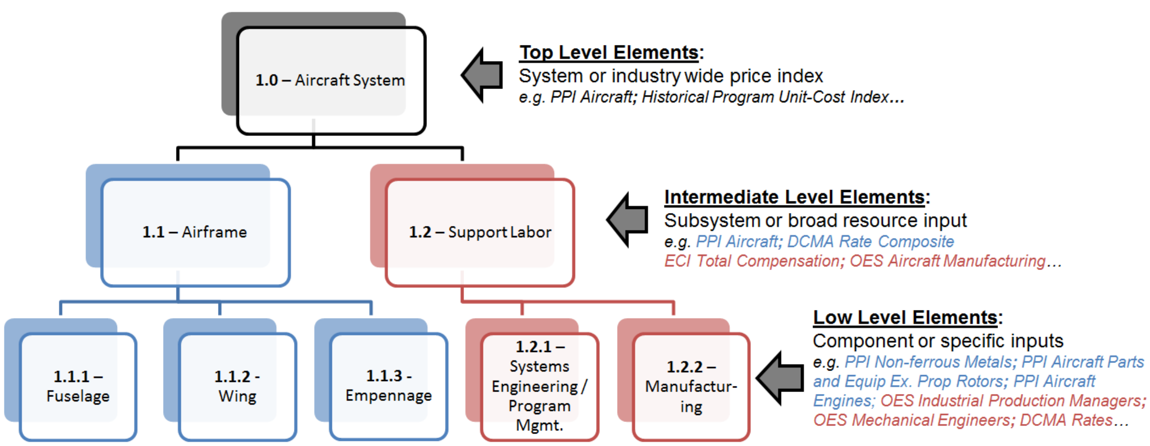
This framework is meant to be a conceptual guide—not a foolproof checklist—so think of it as a brainstorming aid. There may be some types of real price change discussed in this chapter that do not apply to your estimate, or additional types of real price change that are unique to your estimate. Use the ideas in this chapter to help you break down real price change into manageable pieces, use your best judgment to account for it as it applies to your estimate, and remember to always document your reasoning.

A. Framework scales to any level of detail

As you start to identify sources of real price change that apply to your estimate, keep in mind that you are not limited to evaluating real price change at the level of total end-item cost. A weapon system is comprised of various subsystems, each of which can be further described by components, which contain smaller deliverable sets, etc. The Work Breakdown Structure (WBS) or Cost Estimating Structure (CES) you are using for your estimate, and the level of detail therein, may help you identify categories of costs that you want to treat as groups for escalation analysis. The best practice is to assess escalation at a detailed level when time and data permit.

The framework provided in the next section of this chapter can apply to all levels of cost detail. Figure 3-2 below shows a notional aircraft WBS with potential escalation indices that may be useful at each level. Instead of asking, "what part of the observed real price change is due to changes in aircraft prices at large?" you could ask, "what part of the observed real price change is due to price changes in the components or resource inputs to the aircraft?" For example, you might use a Producer Price Index (PPI) for aircraft to understand the market pressures affecting total aircraft system costs. At a lower level of the WBS, you could examine the PPI for aircraft engines, Employment Cost Index (ECI), Occupational Employment Statistics (OES) index, market data on engineering salaries, or other indicators of production cost. See Chapter 6 for guidance on selecting an escalation index suited to various levels of cost detail, and Appendix B for more information about the example indices used in Figure 3-2.

Figure 3-2. Analyze escalation at most appropriate WBS level

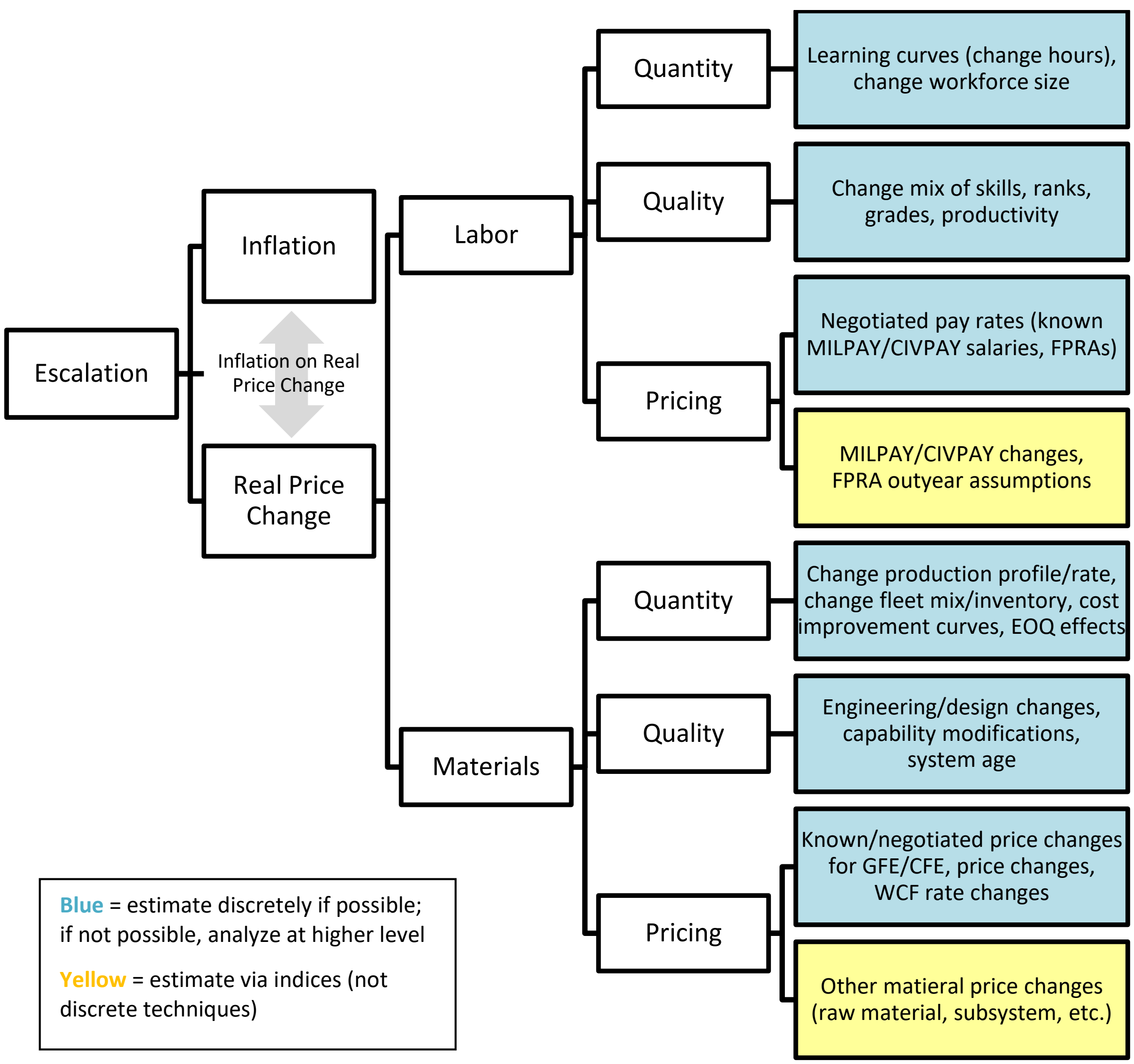


As an everyday example, say you just returned from the grocery store with your receipt and want to estimate what the same "market basket" of goods will cost at some point in the future. Looking at your receipt, you find that there are several ways you could categorize the items, such as produce vs. meat vs. packaged goods, organic vs. conventional items, by individual item, or even at the total level. You could analyze pricing trends for any of these categories depending on what is most useful for your grocery shopping decisions, or based on the availability of price index data for various categories. Likewise when estimating costs for defense items, you should break down the costs into categories that are both useful for other estimating methodologies and well-suited for the application of available indices.

B. Cost estimator's framework for analyzing escalation

Figure 3-3 below presents categories of real price change under a cost estimator-oriented framework. The framework begins with the broad categories of labor and material, to align with common estimating practices. More specifically, goods or services within each of these categories may experience changes in quantity, quality, and/or pricing, causing costs to change over time. The forces described below may be positive, negative, or zero for any given estimate.

Figure 3-3. Cost estimator's framework for analyzing escalation.



1. Quantity changes

Any decision to change the quantity of a good or service estimated will affect its total cost, whether due to government effects (e.g., budget limitations), contractor effects (e.g., capacity limitations), or any other cause. Even on a per-item basis, changes to the total quantity estimated may induce price change due to rate-related effects like learning, productivity, and economies of scale.

Quantity changes are central to cost estimating, and rarely if ever appropriate to model via indices in the same way you would apply inflation. For example, if a program achieves a 10% savings in an input by purchasing an Economic Order Quantity (EOQ), the best way to model that change may be as a step function (e.g., price X until EOQ threshold achieved, then price X * 90% beyond EOQ threshold) independently of the application of generic price indices.

2. Quality changes

The weapons systems for which we estimate costs often evolve over time—for example, an estimate may include variants with different configurations or capabilities, or modifications for planned technological improvements. Some of these qualitative changes may affect costs, either positively or negatively, and we must account for this type of real price change in our estimates.

Some quality changes are easier to model than others. For example, you may be able to infer the quality of a labor hour from the skill level or grade of the worker assigned to complete it, but you may not know whether he or she performed well during that time. Similarly, it may be easy to estimate the cost impact of an engine upgrade if the new engine was a one-for-one, form-fit-function replacement of the previous engine, but difficult to quantify the cost impact of a software release that reduced the frequency of system errors.

Quality changes may be more difficult than quantity changes to estimate discretely, but they are equally important in assessing weapons system costs. You should account for known quality changes when possible, both to explain historical trends and to estimate planned changes in the future.

As discussed in Chapter 2, economists do not generally consider quantity and quality changes to be types of real price change because they have techniques to remove those effects when developing escalation indices. DoD cost estimators, however, are unlikely to find indices that perfectly account for those changes in the highly specialized commodities we estimate; rather, we may use quantity- and quality-adjusted escalation indices from external sources, then account for quantity and quality changes discretely in individual cost models. The framework in this chapter includes quantity and quality changes as a form of real price change to acknowledge the fact that the boundaries between the categories may be blurred for some estimates (especially when little data is available to estimate real price change discretely) and to put those changes in context relative to publicly available indices so you can avoid double-counting or omitting important cost drivers.

3. Pricing changes

The final component of real price change in the framework is the only one that is inherently related to price: any changes to the cost of a product or service that cannot be attributed to quantity or quality changes. For example, a contractor may increase their overhead rates, causing the price to increase for a product or service that has not substantively changed since previous pricing periods. Another example would be an increase in the price of steel due to market-wide changes in supply and demand that are not related to your program of interest, and do not represent a change to the quantity or quality of steel in your estimate. In these examples, you may be able to discretely estimate the real price change impact if you have sufficient information from the contractor for the overhead rate change, or a price index representing market-wide changes in steel prices.

In many cases, however, you will lack sufficiently detailed data to account for such pricing changes discretely in historical data—in other words, you may observe real price change that you cannot definitively explain. For example, you may observe a clear upward trend in costs measured in CY$, but not know the cause. In these cases, you may wish to look up an appropriate price index that is relevant to the product or service you are estimating, or measure the unexplained real price change (e.g., calculate the annual change in CY$ costs, or look for trends in the timing of major price changes) and decide whether you think it will continue in the future.

4. Discrete estimating methods vs. indices

In deciding what types of real price change apply to your estimate (or any portion thereof), differentiate between price changes you can estimate discretely (blue boxes in Figure 3-3) and those you will estimate via indices (yellow boxes). It is generally preferable to use discrete estimating methods whenever possible because they are specific to your estimate, whereas indices that represent broadly defined content may be less appropriate for your estimate or include real price change already captured via discrete methods.

For example, say a particular labor category in your estimate is experiencing wage growth across the economy (i.e., for both DoD and other consumers). If you are already capturing DoD-specific wage increases for that labor category with a Forward Pricing Rate Agreement (FPRA, a discrete method), applying an additional price index for that labor category may double-count some or all of the wage growth you have already included. Figure 3-5 below shows fictitious data from two possible data sources for a labor category's wages: an FPRA for the specific contractor represented in an estimate, and a generic, industry-wide price index for the same labor category.

Figure 3-4. Example: selecting real price change resources for contractor pay rates

Provided by Contractor	
	FPRA
Year 1	$1,000 / man day
Year 2	$1,050 / man day
Year 3	$1,100 / man day
Year 4	$1,150 / man day
Year 5	$1,200 / man day
Year 6+	Not provided

Generic Industry Index[12]	
	Index
Year 1	1.000
Year 2	1.030
Year 3	1.061
Year 4	1.093
Year 5	1.126
Year 6+	Continue 3% increase per year

In this example, you would use the FPRA for years 1-5 because it discretely estimates labor costs for the particular contractor in your estimate; there is no need to apply the generic escalation index because the FPRA already captures all of the growth in these labor costs. Alternatively, if the contractor did not have an FPRA, you could use the generic index for all years (i.e., there is not sufficient information to estimate labor escalation discretely, so estimate escalation via indices).

Notice that the rates of real price change are significantly different between these two options: the FPRA shows escalation at almost five percent per year, and the generic index shows escalation at three percent per year. Making comparisons like this could help you better understand your estimate, as you may wish to research the reasons for the contractor's divergence from industry averages. You may also consider this information in forecasting a rate of escalation for years further in the future; for example, if you apply the FPRA with approximately five percent escalation per year for Years 1-5, you may want to consider whether to use the industry-average index showing three percent escalation for subsequent years or continue the FPRA escalation rate for Year 6 and beyond.

The preceding example required a relatively straightforward decision between a single discrete method and a single index-based method; more often, you will have to

[12] See Appendix B for examples of the types of sources you may use to look up industry-wide indices like this.

decide among multiple options, and the lines between them may be blurry. For example, say you are estimating a program that consumes a large portion of the US market for a particular type of composite material. Some of your discrete estimating techniques, such as production rate, may substantially affect the demand for that material on the open market, and therefore its price—and consequently drive any price index you may be able to find for that composite material. If you apply a generic index for the material in your estimate, you could be double-counting some real price change due to the overlap between your estimate and the market(s) that are relevant to its content.

Distinguishing between discrete and index-based estimating for real price change is important, as *one of the greatest challenges in applying escalation in your estimate will be selecting indices that minimize the overlap with forces you are already estimating discretely*. The boundaries between these categories may be different for each estimate depending on the information available. Toward the goal of producing the most accurate cost estimate possible, you should be able to affirm that you have accounted for forecasted real price change in each element of your estimate, regardless of whether you modeled it discretely, via indices, or a combination of the two methods.

5. Applying the framework given incomplete or ambiguous information

This chapter's escalation framework lists many specific estimating techniques that may not be possible in every estimate or for every commodity analyzed. For example, you may not be able to discretely model quantity changes in labor costs if you know the total cost of a contract but not the number of hours worked. Even worse, you may know the total cost of a contract but not the relative proportions of labor and material costs within it, so the separate categories of Labor and Materials shown in the framework diagram would not apply.

When circumstances prevent you from analyzing escalation at the more detailed levels of the framework diagram, consider analyzing real price change at a higher level of the framework. You will lose granularity of the cost drivers, but may need to accept that limitation when you have insufficiently detailed information. If you measure total real price change at a higher level of the framework, you will capture the net effect of changes in quantity, quality, and pricing.

4. Characterizing Input Types

This chapter will provide guidance on characterizing cost estimate inputs, and will help you determine your "starting point" for the flowchart in Figure 6-1. Chapter 5 will help you decide the type of output you want for a given application, and Chapters 6 and 7 will help you select the indices and calculations required to convert the input to the output.

The dollar types represented in some data sources are easier to identify than others, depending on the consistency of the data collected, the purposes for which the data were collected, and the detail of the accompanying documentation. There are two sets of circumstances in which you may find yourself: (1) your input comes from a source that unambiguously dictates the input type and you must simply characterize it, or (2) your input comes from an ambiguous source and you must seek more information, filling in any gaps with educated assumptions.

Use this chapter as instructions whenever you find an input and are unsure how to use it. The first section describes the information you will need to obtain, and the second and third sections will help you find that information if the data is from a rigidly defined source (section B) or a more ambiguous one (section C). The final section provides additional guidance for dealing with data points that represent a single year, which involve some unique considerations.

A. Information required to understand an input

The following checklist is a preview of a more extensive documentation chapter (Chapter 9) at the end of this handbook. Ideally, you would be able to find all of the information shown in Figure 4-1 for every input value in your estimate, and you would document every output (including intermediate steps) in a similar fashion.

Figure 4-1. Attributes required to precisely characterize inputs and document results.

DOCUMENTATION CHECKLIST

- ☐ **Value**
- ☐ **Transaction year**
- ☐ **Dollar type (TY$ obs, TY$ exp, CY$ obs, CY$ exp, CP$)**
- ☐ **Base year (if CY$ or CP$)**
- ☐ **Index applied (if CY$, CP$, or future TY$), including publication date**

Example 1: $100,000 was expended in FY 2014 in the "Aircraft Procurement, Air Force" appropriation.

- Value: $100,000
- Transaction Year: FY 2014
- Dollar Type: TY$ exp
- Base Year: N/A
- Index Applied: N/A

Example 2: An obligation in the "Aircraft Procurement, Air Force" appropriation was recorded in FY 2014, totaling $22,000 in CY18$, normalized using the "Aircraft Procurement, Air Force" weighted index, published January 2020.

- Value: $22,000
- Transaction Year: FY 2014
- Dollar Type: CY$ obs
- Base Year: FY 2018
- Index Applied: Aircraft Procurement, Air Force (weighted), January 2020

Given that most cost estimates are dense spreadsheets with many inputs in various years and appropriations, it would be cumbersome to list the above attributes in bullet format for every value. Instead, structure your cost estimates so that labels or section headers can document similar inputs simultaneously, or such that pieces of documentation like base years or dollar types can also serve as inputs to functions you will use (e.g., VLOOKUP, INDEX, and MATCH in Microsoft Excel). For example, you may enter the dollar type and reference year of an input near the value itself, and use those descriptive cells to look up the appropriate index value in a table elsewhere in the model. Similarly, you could create a column aligned with your estimate's cost element structure that lists index names for each element, and use a look-up function to pull in the appropriate index values from references tables on another tab. This active documentation adds transparency for others who will review your estimate, improves efficiency of the model, and facilitates changes as you develop your estimate. See Chapter 7 section A for more advice on modeling practices.

When you are ready to begin the calculations listed in Chapter 7 section A, you will need to specify a parameter called $Year_{in}$ to identify the first index value required. The transaction year will be $Year_{in}$ for TY$ inputs, and the base year will be $Year_{in}$ for CY$ and CP$ inputs.

B. Inputs from well-defined sources

Any source that enables you to fully characterize an input according to the Documentation Checklist provided above is considered "well-defined" for the purposes of this handbook. These sources may be ***primary sources***, such as accounting systems or formal budget documents (which record costs in TY$), or ***secondary sources***, such as a well-documented cost estimate from another analyst (which could be in any type of dollar depending on the analysis).

Primary-source data is in TY$ (either expenditures or obligations) because it represents real-world transactions that have not been altered for the purposes of calculations or comparisons. You should try to start with data from primary sources whenever possible so that you will know the details of every transformation executed, thus avoiding the uncertainty that comes with using previously-manipulated secondary-source data. Some common primary sources of cost data include:

- For TY$ obs:
    - Budget documents
    - Acquisition Program Baseline (APB)
    - Selected Acquisition Report (SAR)
    - Air Force Total Ownership Cost (AFTOC)
- For TY$ exp:
    - Cost and Software Data Report (CSDR)
    - Contractor Performance Report (CPR)
    - Invoices
    - Price lists (e.g., Federal Logistics record [FEDLOG], Army Price and Credit Table [APACT], Air Force D043)
    - Naval Visibility and Management of Operations and Support Costs (Naval VAMOSC)
    - Operation and Support Management Information System (OSMIS)

Some of the above sources also offer costs normalized to CY$ or CP$ for convenience. You should avoid using these options when possible because using pre-normalized values as inputs can cause distortions if you don't know exactly how the values were produced. For example, the indices applied in a database or previous cost estimate may be out of date by the time you retrieve the values, and any calculations you perform using newer indices will include the effect of deltas between the indices. You may also find that systems with TY$ exp data also offer CY$ exp versions (rather than CY$ obs), which are not ideal for cost estimate inputs. The impact of any distortions may be small, but could cause confusion when comparing results with those of another analyst who pulled the data from a different source or at a different time (see Chapter 8 section B for more information on the impact of using inappropriate or mismatched indices).

Starting with raw data from a primary source, you will likely perform multiple rounds of conversions prior to generating your final cost estimate—the output of each conversion will become the input of the next (see Figure 5-2). For example, you might retrieve TY$ obs historical data from a primary-source database, de-escalate it to CP$ to calculate an average factor across multiple years, escalate that factor to each year of the estimate for your TY$ obs output, and then deflate those costs to CY$ obs for a threshold report. Each of these steps treats the output of the previous step as the input of the next: TY$ obs to CP$, CP$ averaged over multiple years (no dollar-type change occurs in this step), CP$ to TY$ obs, and finally TY$ obs to CY$ obs. Since you are doing each step in this process yourself, you can ensure that all indices include appropriate content and are up-to-date. As long as you correctly identify the desired output type for each step (as described in Chapter 5) and maintain good documentation (see Chapter 9) to keep track of what the value represents, you will minimize the potential for errors and bias in your results.

C. Inputs with missing or ambiguous identifying information

Cost estimators often have to use imperfect data in order to produce an estimate. This section will provide recommendations for investigating data that you cannot fully describe according to the instructions in the previous section.

First, there are two attributes of an input that you simply must know in order to use a value: the value itself, and the transaction year that puts it into context with respect to time. If you know neither how much money was or will be spent, nor the timing of the transaction, any further calculations to adjust for inflation or escalation will not provide a meaningful result.

If any of the other attributes listed in the documentation checklist (reproduced here) are unavailable, unclear, or untrustworthy, you should first attempt to get more information from the data source.

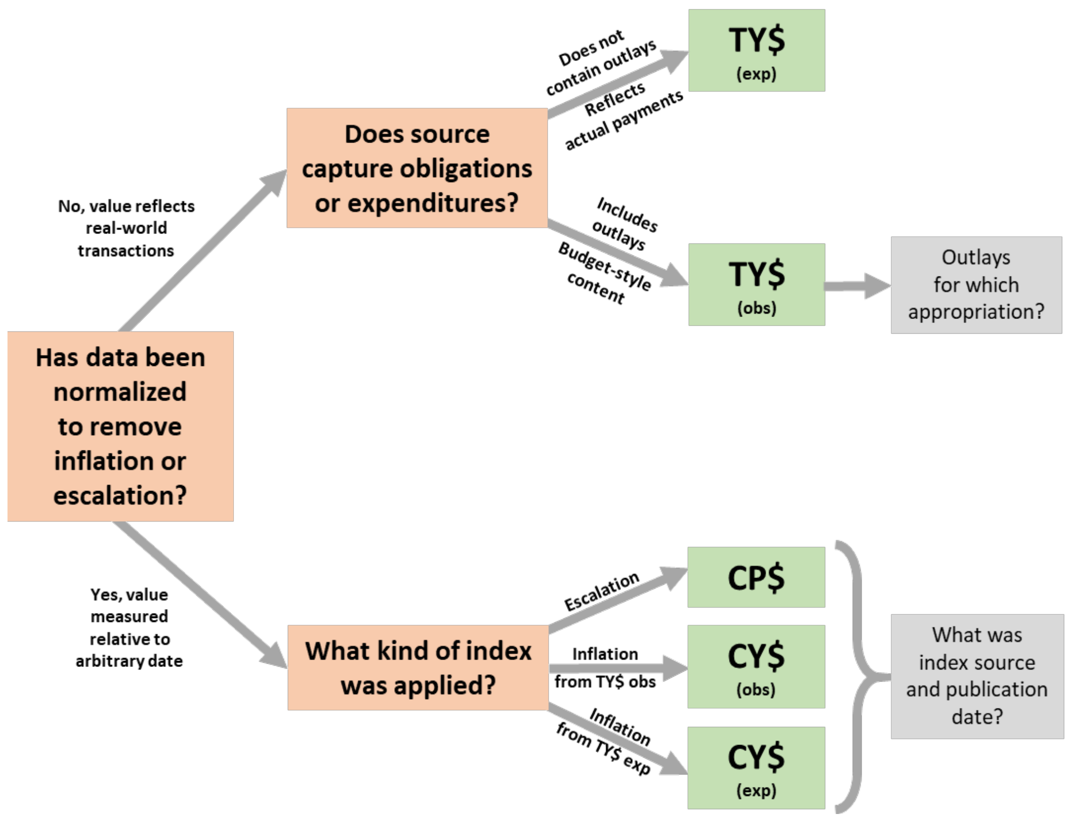
DOCUMENTATION CHECKLIST

- ☐ **Value**
- ☐ **Transaction year**
- ☐ **Dollar type (TY$ obs, TY$ exp, CY$ obs, CY$ exp, CP$)**
- ☐ **Base year (if CY$ or CP$)**
- ☐ **Index applied (if CY$, CP$, or future TY$), including publication date**

1. Questions to ask when clarifying data attributes

Many data sources label costs in ambiguous ways, or the label provided may not align with the best practices in this handbook. For example, you may find data that is not labeled at all, or that has labels like "2020 constant dollars," "FY 2020 $," or "BY2020" that do not follow standard nomenclature. If you can find a point of contact that is knowledgeable about the data, ask questions from the flowchart in Figure 4-2 from left to right until you are confident that you have fully characterized the input. The flowchart is a visual representation of the definitions provided in Chapter 2, so refer back as needed for more details. The gray boxes on the right include additional questions about indices involved in certain inputs, which will help you identify the indices to use in your own calculations (see Figure 5-2 and Chapter 6).

Figure 4-2. Flowchart to identify unknown input types ("Carrot Chart").



2. How to make assumptions for unknown input attributes

When there is no way to obtain further information about an ambiguous input, ask yourself whether you truly need to use it or can obtain alternative data from a more reliable source. If you must use the input, make assumptions as needed to select an appropriate index value for calculations; use your best judgment, the advice of colleagues, and best-practice guides such as this one to inform your decisions, and make sure to document your actions and the reasons for your lack of confidence in the data. You may be concerned that decision makers will find your lack of faith disturbing, but a realistic understanding of risk is important for acquisition decisions. The dollar impact of any incorrect assumptions will likely depend on the period of time involved—for example, the potential for error will be greater in a conversion from 2005 to 2020 than in one from 2015 to 2020.

In the absence of any information that would suggest otherwise, this handbook recommends assuming that a cost with unknown attributes represents a TY$ exp in the labeled transaction year. Subsequent calculations will induce a slight error if the cost actually represented TY$ obs or CY$ obs because they would neglect the effect of escalation or real price change, respectively, over the course of the outlay period.

D. Using single-year expenditures as CP$ inputs

Although some inputs have well-defined attributes that dictate their dollar types and subsequent use in calculations, a useful shortcut for cost estimating allows you to treat TY$ exp and CP$ as equivalent in cost models. In a given transaction year, the value of a TY$ exp is equal to its corresponding CP$ value when normalized to that year (i.e., the base year is the transaction year). For example, an expenditure (TY$) of $100 in FY20 means the price in FY20 was $100, or CP20$ equals $100. This relationship does not exist between TY$ obs and CP$, however, because the TY$ obs value accounts for prices in later years as well (i.e., during the outlay period).

To demonstrate this input flexibility, say you are estimating government manpower costs for a unit. First you obtain FY20 salary data by rank and grade for all personnel types in the unit. A salary is a TY$ value because it has real world significance: the amount will be transferred in a transaction between the employer and employee, and it has not been normalized to CY$ or CP$ using any indices. More specifically, you may treat these salaries as expenditures in FY20 because the value will be fully paid in that year.[13] The typical process for estimating manpower costs is described below, and further notes will describe what is happening in each step in terms of escalation and inflation:

1. Obtain headcounts required for each year of the estimate, broken out by grade, rank, location, etc., as needed.
2. Obtain salary data (TY$) for the current fiscal year (FY20 in this example), including grade, rank, location, special pays, etc., as needed.
3. Multiply headcounts for each year by corresponding salaries for the current fiscal year (FY20).
4. Escalate each year’s manpower cost to the year of the estimate (TY$) using an appropriate index for military pay, civilian pay, contractor pay, etc.

[13] You may find that you should treat salaries as obligations in certain situations if some of the payments will cross fiscal years (i.e., follow an outlay profile into a second year). This point emphasizes the importance of knowing your data, but we will treat a salary as a one-year expense for the sake of the example presented.

5. Deflate each year's entry to the base year of the program (CY$) using an inflation index for final reporting.

In step 2, you retrieved salary data that is best described as a TY$ exp, as discussed previously. In step 3, you created a CP20$ estimate for the headcounts included in the unit; this cost profile is CP$ because the year-to-year variation in costs is due to changes in quantity (number of people) or quality (rank, grade, etc.) within the unit, but not due to any price changes (because the price is a constant FY20 salary based on type of person).[14] In step 4, you turned the CP20$ estimate into a TY$ estimate for each year (transaction year), and then deflated the estimate to CY$ in Step 5 for use in comparisons or reporting requirements.

What happened between Steps 2 and 3? You started with a TY$ exp (salary) as your input and wound up with a CP20$ profile, even though you didn't use any indices to convert from TY$ exp to CP$. In modeling situations like this, you are really treating the input as a CP20$ value, which is permitted because a TY$ exp in FY20 is the same when normalized to CP20$ (the index value would be 1). The salary in FY20 is both a real-world value (TY$) and a *constant price* throughout the year in the most literal interpretation of "CP$."

This flexibility does not exist for inputs that are phased over multiple years. Although you could treat each year individually as a TY$ exp, or CY$ or CP$ normalized to the base year of that transaction, there is no use case for doing so that is evident to the writers of this handbook. For example, if you obtained costs for FY18-FY20 from a database containing TY$ exp, you could treat the FY18 costs as TY$ exp in FY18, or as CY18$, or as CP18$... and you could treat the FY19 costs as TY$ exp in FY19, or as CY19$, or as CP19$... and likewise for the FY20 costs, but the resulting collection of CY$ and CP$ in different base years is not easy to use in a cost model. Such values are effectively in different units of measurement, and cannot be combined in any calculations (see Chapter 8 section A). Rather, you would treat the FY18-20 data as TY$ exp for each of those transaction years, and treat the data as a block for calculations; for example, you may normalize each year's value to CP18$ using an escalation index so that the transaction years remain evident (i.e., you can still see how much was spent in each year), but they are all normalized to the same base year.

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[14] According to older definitions, the action in Step 3 would have been considered the creation of a "base year" or "constant year" profile, rather than CP$ as presented here. The publication of this handbook has not changed the basic process of performing calculations such as these, in which you estimate costs using some "flat-line" profile (see Chapter 2 section F) and apply an index to produce TY$. The changes in terminology since 2015 have simply clarified the fact that the index used to produce a TY$ in this process should be an escalation index, and that an additional step of deflating that TY$ estimate to CY$ using an inflation index produces a unique output for reporting purposes.

5. Selecting Output Types

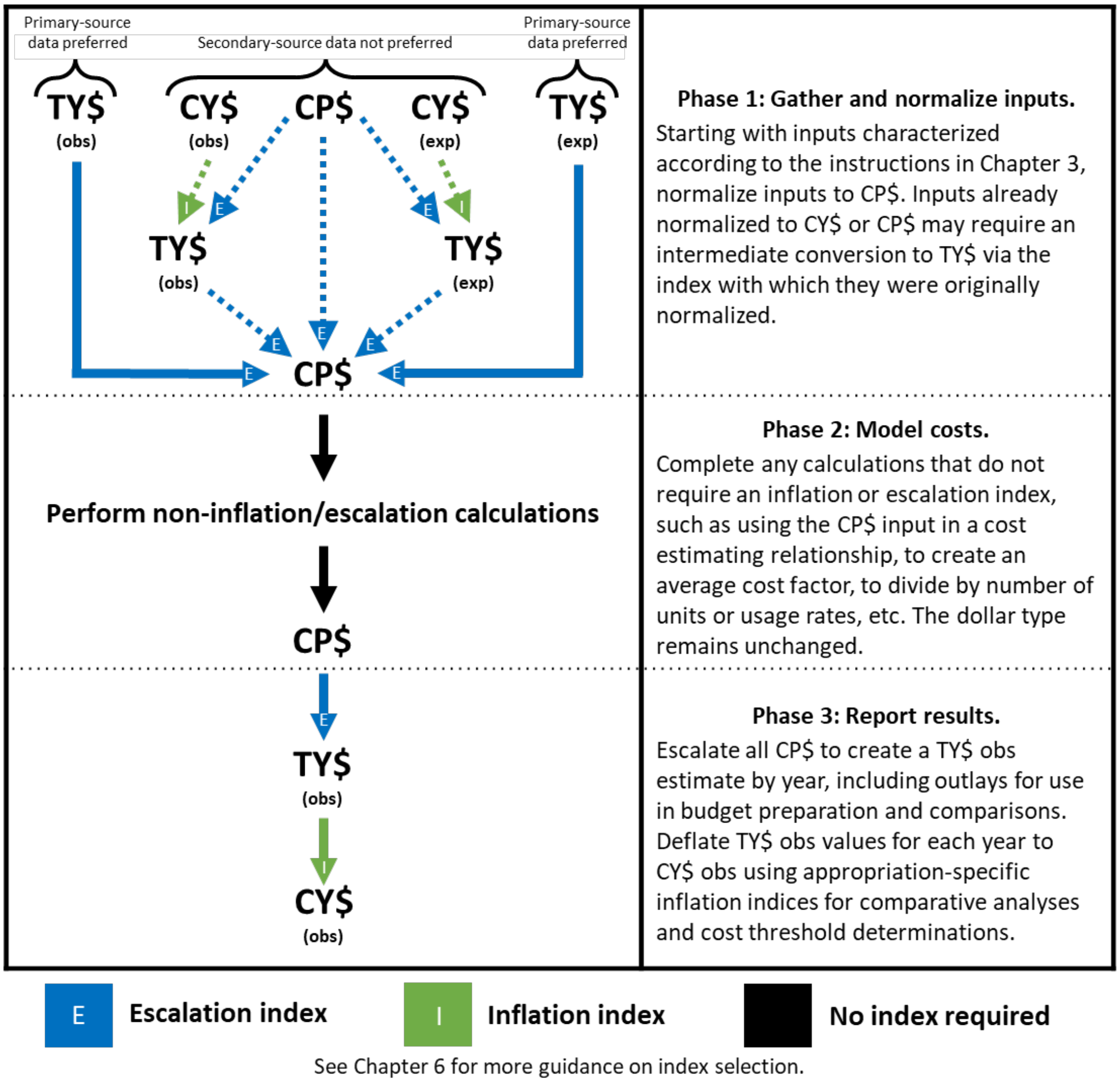
Most of the inputs in your cost estimate will undergo multiple rounds of calculations before reaching a value for presentation, with the output of one calculation becoming the input of the next. This chapter explains the rationale for using various dollar types for each input-output conversion in your estimate, and discusses the potential pitfalls of producing an inappropriate dollar type. As a quick reference, Figure 5-1 below lists the circumstances under which you should or should not use particular dollar types.

Figure 5-1. Applications of various output types.

	Recommended for…	**Not recommended for…**
CP$	*Intermediate calculations:* • Average cost factors • Cost Estimating Relationships (CERs) • Cost Improvement Curves (CICs) • Visualizing programmatic trends	*Reporting final values:* • External reports beyond DoD cost community, unless well-documented and necessary to explain cost estimate methodology
TY$ obs and CY$ obs	*Reporting final values:* • Total costs • Reports for stakeholders beyond DoD cost community: – Budget (actual budget values in TY$ obs, with CY$ obs for comparison in some displays) – Acquisition Program Baseline (APB) – Selected Acquisition Report (SAR) – Analysis of Alternatives (AoA) – Business Case Analysis (BCA) – Affordability Analysis	*Intermediate calculations:* • Calculations other than addition and subtraction with other values of same type (and same base year if CY$ obs) • Average cost factors across multiple years • CERs • CICs
TY$ exp and CY$ exp	*Displaying data obtained from primary sources that capture expenditures*	*Intermediate calculations or reporting final values (see above)*

Additionally, Figure 5-2 provides a generic flow diagram of a cost estimate from initial data collection to the final reporting of results, showing the dollar type you should use at each stage. Section A of this chapter describes the initial normalization of inputs in detail, section B explains why you should perform intermediate calculations in CP$, and section C explains why you should report final costs only in TY$ obs and CY$ obs.

Figure 5-2. Output types at various points in cost estimating process ("Pitchfork Chart").



A. Normalizing data for use in calculations

Cost analysts obtain data from many different sources, and typically must convert them to comparable units prior to performing calculations or reporting results. In Phase 1 of Figure 5-2, this normalization process shows that you should normalize all inputs to CP$ prior to using them in cost estimating relationships, cost improvement curves, and other standard cost estimating methodologies.[15] Normalizing a set of TY$ costs using a particular escalation index (e.g., five years' worth of historical data for a given cost element) to CP$ restates the costs in a common unit so that they can be used together in calculations. Note that CP$ produced via different escalation indices (e.g., aircraft production index vs. engine production index) *cannot* be used together in calculations, as the units of measure (as captured by each index) are not the same.

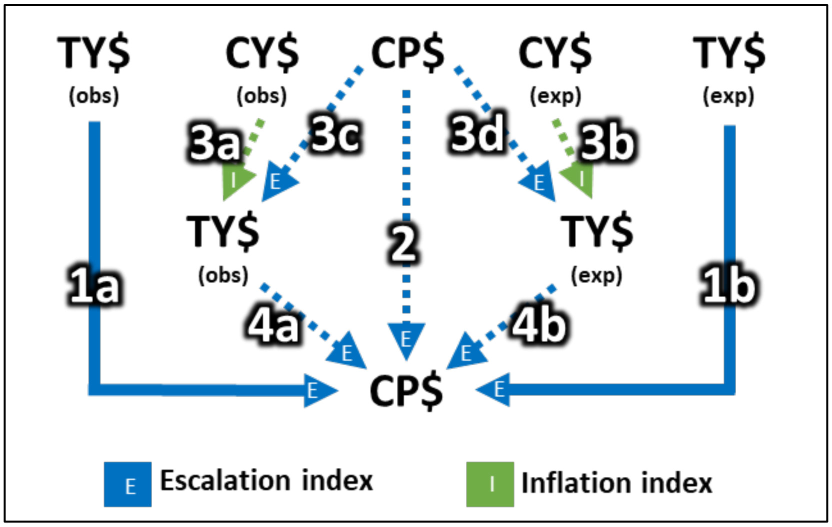
Prior to the introduction of CP$ as a concept around 2015, cost estimators were generally taught to normalize costs to "base year dollars" or "constant year dollars" prior to using them in calculations. This handbook recommends normalizing all the way to CP$ because doing so removes the effect of as many time-correlated economic phenomena as possible (i.e., real price change in addition to inflation). Normalizing data to CY$ leaves behind historical real price change, which may not be representative of future escalation. Removing *all* escalation prior to performing calculations provides more time-independent results, and then you can apply forecasted escalation rates to the results with less risk of double-counting.

The process shown in Figure 5-2 for normalizing each type of input is reproduced in Figure 5-3 below for a more detailed explanation of each labeled arrow. While this section deals only with reaching CP$ for further calculations, you will find information about index selection for all kinds of conversions in Chapter 6. Although this graphic may appear confusing at first, keep in mind that all paths lead to CP$ for use in subsequent calculations; the graphic simply accounts for all scenarios you may encounter when collecting inputs, with five possible dollar types and, for pre-normalized data in CP$, varying degrees of satisfaction with the index that originally produced them.

In the course of following the steps below, you should also consider whether to normalize your input for features like fees, overhead (e.g., G&A, FCCM), and other components. For example, you may be using a historical contract cost that includes a particular fee percentage, but plan to use the input in a CER built with data that did not include similar fees. Since these types of costs are often applied as percentages on top of real-world costs (TY$), you should remove them prior to normalizing the inputs to CP$; if you normalized the costs prior to removing a fee percentage, there would be a slight error in the results.

[15] Calculations that do not involve time-correlated data are not discussed in this chapter. For example, you may divide any cost type (TY$, CY$, or CP$) by number of units produced, number of hours flown, number of miles driven, etc., without prior normalization if the costs are already in the desired dollar type. You should document the cost type of the numerator in metrics like these (per the instructions in Chapter 9) so other analysts will know whether the costs were normalized relative to an index.

Figure 5-3. Normalizing inputs (Phase 1 from Figure 5-2).
Calculations along solid lines are preferred over those along dashed lines.



- For **Arrows 1a, 3a, 3c, and 4a**, the notes below will call for the use of weighted indices. In most cases, you will also need the underlying raw index (i.e., without the outlay profile represented in the weighted index). For the sake of readability in the following bullets, the references to weighted indices for which you will also need the underlying raw index will be marked with an asterisk (*). See Chapter 7 section A for details on these calculations.
- **Arrows 1a, 1b:** The use of TY$ inputs (either obligations or expenditures) is preferred because they represent primary-source data that has not been normalized by information systems or other analysts (see Chapter 4 section B). When converting TY$ data to CP$ for further calculations, you may select any escalation index that is appropriate for your data and analytical purposes.
  - **Arrow 1a, TY$ obs to CP$:** Use a weighted* escalation index.
  - **Arrow 1b, TY$ exp to CP$:** Use a raw escalation index.
- **Arrow 2:** You may follow this arrow if both of these conditions apply: (1) the index used to generate the CP$ input includes appropriate content for your purposes, and (2) the index is compatible with any further calculations you will complete, such as CERs. For example, say you have a CP$ input that was normalized using an escalation index for commercial helicopters. If you also would have chosen the commercial helicopters index, and plan to use the CP$ value as an input to a CER built with CP$ data normalized with the same helicopter index, you may use the CP$ input directly (note that you may need to change the base year to match). If, however, you plan to use the helicopter-CP$ input in a CER developed using a generic aviation index, you should follow arrow 3c or 3d instead. In that case, arrows 3c and 3d would be the helicopter escalation

index (weighted* or raw, respectively), and subsequent use of arrows 4a or 4b would involve the generic aviation escalation index (weighted* or raw, respectively).

- **Arrows 3a-3d:** For CY$ inputs and CP$ inputs for which the conditions above (for arrow 2) are not met, you must attempt to "undo" the normalization that produced them. In other words, you must convert them to TY$ as an intermediate step, getting as close to the original primary source data as possible. To minimize error in this step, you should ideally use the *same exact index* that produced the CY$ or CP$ input from the original primary source data.[16] If you do not have a copy of the original index (the most likely scenario), use your best judgment to select as close a substitute as possible. [17]
  - **Arrow 3a, CY$ obs to TY$ obs:** Use a weighted* inflation index (matching the original index if possible) to convert to TY$ obs, then follow arrow 4a with your preferred weighted* escalation index to convert to the desired CP$.
  - **Arrow 3b, CY$ exp to TY$ exp:** Use a raw inflation index (matching the original index if possible) to convert to TY$ exp, then follow arrow 4b with your preferred raw escalation index to convert to the desired CP$.
  - **Arrow 3c, CP$ to TY$ obs:** Use a weighted* escalation index (matching the original index if possible) to convert to TY$ obs, then follow arrow 4a with your preferred weighted* escalation index to convert to the desired CP$.
  - **Arrow 3d, CP$ to TY$ exp:** Use a raw escalation index (matching the original index if possible) to convert to TY$ exp, then follow arrow 4b with your preferred raw escalation index to convert to the desired CP$.

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[16] You are most likely to possess this information if you have access to a detailed cost model in which you can trace the formulas that produced the CY$ or CP$ value you want to use. If that is the case, you should use the primary source data itself (following arrows 1a or 1b) rather than starting from normalized versions of the same data in CY$ or CP$.

[17] The judgment calls that may be required for the four arrows in this group are more difficult for CP$ inputs than for CY$ inputs. There is a wider range of potential indices that could have produced a CP$ input (any escalation index) than could have produced a CY$ input (inflation indices only). Although there are several ways to calculate inflation, DoD cost estimates all should use the GDPPI (which is the basis of the Comptroller-provided inflation indices) and only differences in the index publication date or appropriation are likely to skew the results. For CP$ inputs, blindly selecting an escalation index to try to recreate the original TY$ value could create a TY$ value that has no real-world relevance. You should generally avoid using pre-normalized inputs for this reason, as described in Chapter 4 section C. See Chapter 8 section B for more information on the possible error a poor assumption could introduce.

- **Arrows 4a-4b:**
    - **Arrow 4a:** TY$ obs to CP$: Use a weighted* escalation index.
    - **Arrow 4b:** TY$ exp to CP$: Use a raw escalation index.

B. Output types for use in calculations (CP$)

Once you have normalized your inputs to CP$, you can proceed with the non-inflation and non-escalation calculations you normally complete for a cost estimate. For example, you can use multiple years' worth of CP$ costs to generate an average annual cost factor, use the normalized costs to build or use a CER, or calculate a cost improvement curve.[18] As previously discussed, calculations such as dividing costs by number of units or measures of operating tempo are not discussed in detail; whatever dollar type went into those calculations will be the dollar type of the numerator coming out (e.g., TY$ obs divided by flying hours yields TY$ obs per flying hour).

In addition to providing instructions, the following sections demonstrate the fact that index selection for initial data normalization can have a substantial effect on subsequent calculations and the nature of the relationships observed in the data. Future analysts may need access to the exact indices you applied prior to performing more advanced calculations, so you should be sure to include full copies of such indices in your project documentation.

1. Average cost factors

For some cost elements, you may simply take an average of historical costs to create an annual cost factor for extrapolation to future years. For example, say you obtain a five year history of annual training costs from 2015 to 2019, and want to use the average of those historical costs as the basis of a forecast for 2020 (assume training costs use one-year money, which allows us to ignore outlay profiles for this example and use only raw indices). Notional TY$ exp data and two relevant (notional) indices are provided in Figure 5-4 below, and you normalize the costs to both CP19$ and CY19$ exp for comparison.

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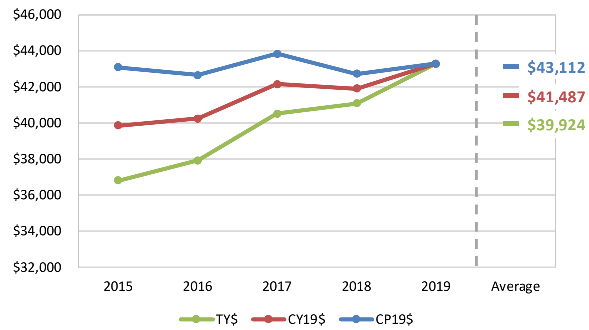
[18] This chapter does not discuss learning curves on their own because they are performed on labor hours, not costs. A cost improvement curve is functionally similar to a learning curve, but used when the labor hours are not known or when the analyst wishes to analyze efficiency improvements at a more aggregated level.

Figure 5-4. Calculating average cost factors from historical costs.

Fiscal Year	TY$	Escalation Index (BY19)	Inflation Index (BY19)	CP19$ (=TY/esc)	CY19$ (=TY/inf)
2015	$ 36,819	0.8548	0.9238	$ 43,073	$ 39,854
2016	$ 37,917	0.8890	0.9423	$ 42,651	$ 40,238
2017	$ 40,518	0.9246	0.9612	$ 43,824	$ 42,155
2018	$ 41,079	0.9615	0.9804	$ 42,722	$ 41,901
2019	$ 43,289	1.0000	1.0000	$ 43,289	$ 43,289
Average	**$ 39,924**			**$ 43,112**	**$ 41,487**



Out of the three options for averages calculated above, you immediately rule out using the average calculated in TY$ because it has lost any connection to a particular point in time (i.e., the average is a mixture of transaction years, and there is no unifying base year for TY$). You decide to convert the CP19$ and CY19$ averages to TY$ in 2020, which is the value you are forecasting, to compare the results. Let's assume forecasted escalation from 2019 to 2020 is four percent (index = 1.04), and forecasted inflation is two percent (index = 1.02).

- Escalate CP19$ average to TY$ in 2020: $43,112 × 1.04 = $44,836
- Inflate CY19$ average to TY$ in 2020: $41,487 × 1.02 = $42,317

Are these results just different or is one better than the other? The CP$ method provides a more accurate TY$ forecast because it does not suffer from three problems that exist in the CY$ method. First, the average calculated in CY19$ included some real price change that occurred over the historical period: a clear upward trend in costs remained even after inflation was removed, indicating that the average includes some unexplained time-correlated variation. That unexplained variation represents an error term that will persist if you use the CY19$ average in future calculations. Second, the conversion of the CY19$ average to TY$ in 2020 applies only inflation, and omits forecasted real price change. Although there is some real price change already "baked into" the CY19$ average as previously discussed, this effect is difficult to conceptualize and separate from the anticipated real price change in the future. Third, and more generally, this example used TY$ exp data and CY$ exp are not ideal for cost estimating purposes because they are not compatible with budget analyses, which are obligations-oriented. The CP$ method is preferred, as all escalation was removed prior to calculating the average (so no real price change was baked into the result), and the full amount of forecasted escalation was then applied to reach TY$.

2. Cost Estimating Relationships (CERs)

A cost estimating relationship (CER) is a parametric model that seeks to determine the statistical relationships between program costs and the characteristics of sampled weapon systems. Cost analysts use CERs to predict the cost of a future program given its planned or known characteristics. Most CERs gather data for programs from different points in time, and each program's cost must be normalized to a common base year in order to eliminate the effect of program timing on the relationship between cost and technical characteristics.

To remove as much time-correlated price change as possible, you should normalize costs to CP$ for use in CERs. When building a CER, select an escalation index that is appropriate for all data points—you may have to use an index that is slightly broader in scope if a more narrowly defined one is not appropriate for all data to be included. When using a CER, the index you use to normalize your inputs to CP$ (see section A above) should be the same index as was used to generate the CER.[19] The following example will show how the cost normalization choice affects the estimated relationships for a given set of data.

Suppose you are estimating the Detail Design phase for a new ship, slated to start in 2018, based on actual costs for analogous programs. For simplicity, assume weight (measured by full-load displacement in thousands of long tons) is the sole cost driver. During Detail Design, the DoD primarily buys labor to solve system design problems, and often the assumption is that a relationship exists between the cost driver (weight) and the amount of resources (i.e., the number of labor hours). In this example, ship design resource costs have escalated at 3.5 percent as opposed to 2.0 percent for the economy-wide measure of inflation. Normalizing historical TY$ with escalation will remove distortions to the purchasing power of the dollar with respect to ship resource costs, revealing the "true" underlying relationship between weight and resources (labor hours). Figure 5-5 below shows the available information for six analogous programs, with some costs normalized to CY$ or CP$ with a base year of 2016.

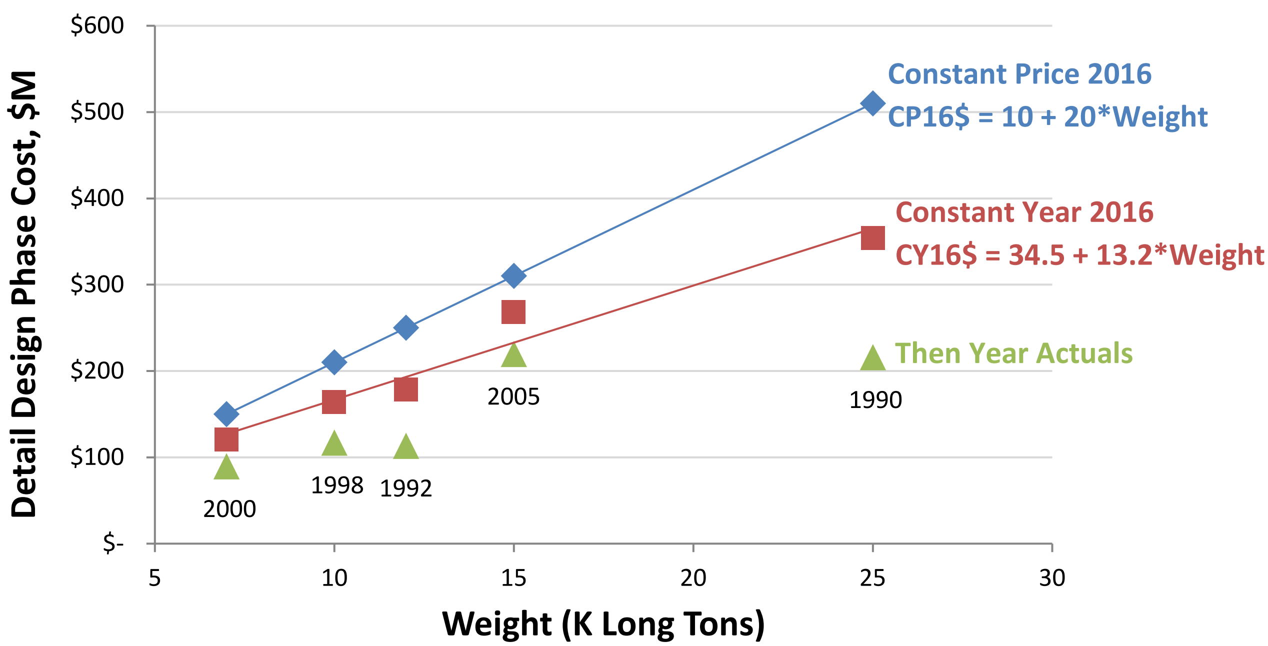
[19] You should use an updated version of the same index, if available. Most indices are published annually or quarterly, and later releases will gradually replace forecasted values with actuals as they become known. If you use an outdated index with forecasted values that did not match what actually occurred, you will introduce error into your results.

Figure 5-5. Analogous program information for CER example.

Assumptions: Inflation = 2.0%, Escalation = 3.5%						
Year	(A) Ship Weight (K LT)	(B) TY$M obs	(C) Escalation Index, Wtd.	(D) CP16$M (=B/C)	(F) Inflation Index, Wtd.	(G) CY16$M obs (=B/F)
1990	25	$215.2	0.422	$510.0	0.609	$353.6
1992	12	$113.0	0.452	$250.0	0.633	$178.4
1998	10	$116.7	0.556	$210.0	0.713	$163.6
2000	7	$89.3	0.595	$150.0	0.742	$120.3
2005	15	$219.1	0.707	$310.0	0.819	$267.5

Because escalation in ship design resource costs have outpaced inflation, the historical programs' costs viewed in CP16$ are higher than in CY16$. A scatterplot with cost as a function of weight is shown in Figure 5-6 below, and highlights the different views of the relationship. Note that the CER performed in CY$ returns a shallower slope (an additional 1,000 tons of weight costs CY16 $13.2M compared to CP16 $20M).

Figure 5-6. Cost Estimating Relationships in CY$ vs. CP$.



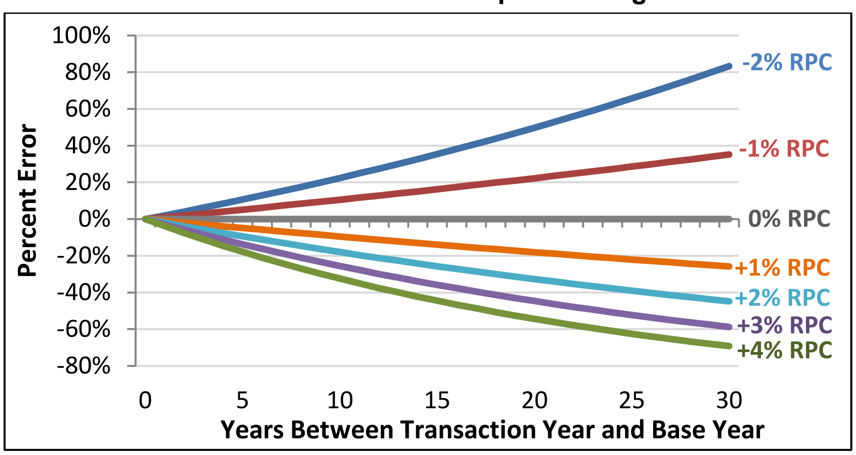
The example data assumes that ship weight has a perfect linear relationship with the analogous Detail Design phase costs when measured in CP$. The relationship exists between weight and escalation-adjusted CP$, and not inflation-adjusted CY$, because it is assumed that ship development of a given weight requires a certain amount of resources, not dollars.[20] The result should be a CER with improved statistics. The relationship takes the form:

$$CP16\$ = f(Weight) = \$10M + \$20M * Weight\ (K\ LT) + \varepsilon$$

The equation states that ship Detail Design would cost on average $10M in CP16$ plus $20M for each additional 1,000 tons. (The epsilon reflects a standard error term reflecting all other factors not accounted for by weight.) If the new ship program is planned to weigh 30,000 long tons, the CP$ CER would predict a cost of ($10M + $20M × 30K LT) = CP16 $610M. The CY$ CER, however, would predict a cost of ($34.5M + $13.2M × 30K LT) = CY16 $431M. Converting both of these to TY$ obs for 2018 (the start of Detail Design) returns final TY$ Detail Design costs of $674M for the CP$ method and $456M for the CY$ method—a difference of 32 percent.

Although the previous example compared CERs built in CP$ versus CY$, similar deltas in the output could arise from choosing different escalation indices (i.e., CP$ produced via indices with different escalation rates). It is important to select an escalation index that is appropriate for the programs whose data you are using, otherwise you could distort the relationship between costs and technical parameters. Errors in characterizing the inputs for a CER (such as transaction year) or selecting an appropriate escalation index will result in a CP$ that is too high or too low, depending on the length of time over which the cost is normalized (i.e., the time between transaction year and base year) and the rate of escalation (see Figure 5-7).

Figure 5-7. Error in normalizing to CP$ (relative to CY$) depends on time period of normalization and rate of real price change.



[20] It would also be valid to apply an escalation index measuring the quality-constant costs of "representative" Detail Design outputs (e.g., ship engineering documents and models). This application assumes the underlying relationship exists between ship weight and dollars, but such escalation indices for unique defense outputs often do not exist. Analogous commercial indices may also be lacking. See Chapter 6 for additional insight on selecting the proper escalation index.

This percent error in costs will cause a distortion in the alignment of data points and therefore the coefficients of the CER equation. To avoid this possible error when building a CER, you must first accurately characterize each data point per the instructions in Chapter 4. Second, follow the guidance in Chapters 3 and 6 to ensure that you select an index that is relevant to each data point (e.g., if you are creating an engine CER and have two different types of engines, you should use a generic "engines" escalation index rather than a more specific index that only applies to some of the data points, or a mixture of more specific indices).[21] More information on the effect of index selection and other advanced CER development topics is available in Appendix E, including considerations for CERs that use technical characteristics that are themselves correlated with time (e.g., weight has been steadily increasing or decreasing from one program to the next chronologically).

3. Cost Improvement Curves (CICs)

When line workers perform repetitive tasks in the production of large complex end items in an environment of continuous pressure to reduce costs, they learn to become more efficient and their processes improve, resulting in fewer direct labor hours being needed to produce each subsequent item. Experience shows that for every doubling of cumulative production quantity, touch-labor hours tend to decrease by a fixed percent, as long as the increase in production quantity is within the capacity limits of the facility, process, and/or workforce. This learned efficiency can be measured in labor hours to produce a "learning curve (LC)," or in dollars to produce a "cost improvement curve (CIC)." When analyzing labor costs instead of hours, the data must be normalized to remove the effect of escalation and expose learning that occurs on the underlying labor hours.

Normalization for dollar types does not affect LCs because they are measured in hours rather than dollars, whereas the normalization required to generate a cost improvement curve (i.e., the amount of escalation removed) does affect projected cost savings from learning. You should refer to Chapter 3 for guidance on removing pricing effects for these calculations, as it can be difficult to tease apart the pricing effects that you want to remove from any quantity- and quality-driven variation you may want to preserve.

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[21] If you are unable to find an escalation index that is appropriate for all data points, you should consider whether the data share enough common characteristics to make them appropriate to combine in a CER.

With information on hours, you could regress the hours-per-unit on the quantities and estimate a learning slope and a first-unit (T_1) cost that define the LC (see the link below[22] for more information on these terms and calculations). Lacking data on hours, you can use the *dollars*-per-unit to back into the underlying learning which occurs on labor *hours* (thus producing a CIC). Because the purchasing power of the dollar has changed over time, you cannot estimate the learning on TY$ without unintentionally building changes in time-correlated labor prices into the equation.

In the following example, you will determine the cost of seven new annual production lot buys that span years 2017-2023. Assume that labor costs are known to be $10 per hour in 2016, which has experienced, and is expected to continue experiencing, 2.00% real price change over a 2.00% inflation rate (or an escalation rate of 4.04%).

A learning curve for this data would produce a learning slope of 87.4% and a T_1 cost of 157 hours. This learning curve estimates labor hours as a function of cumulative quantity, the proper object of learning. Projected labor rates can then be applied to estimated hours to derive a total cost. Figure 5-8 shows this learning curve calculation (for normal program data) along with several examples of CICs to illustrate a variety of approaches: Table 1 shows the learning slope and T_1 hours, which is generally preferred when available, and Table 2 shows three possible CICs, generated for CY$ and two potential CP$ options.[23]

[22] https://www.dau.edu/cop/ce/DAU%20Sponsored%20Documents/Learning%20Curve%20Workshop%20Unit%20and%20Cum%20Avg.pdf

[23] Note that the CY$ presented in this example represent CY$ exp because they were produced from TY$ exp inputs. As shown in Figure 5-1, you should not use CY$ exp to build CICs—this example simply shows CY$ exp for comparison, and demonstrates the fact that building a CIC with CY$ exp produces a result that fails to match the result from a corresponding learning curve.

Figure 5-8. Learning Curves vs. Cost Improvement Curves and the impact of index selection.

Table 1. Learning Curve: Hours per unit are known or can be calculated.

Year	Cumulative Quantity (Midpoint)	Avg. Unit Cost (TY$)	Hourly Labor Rate (TY$)	Avg. Hours per Unit
2010	7.5	$838.3	$7.885	106.3
2011	29.7	$667.4	$8.203	81.4
2012	50.0	$627.7	$8.535	73.5
2013	70.2	$611.6	$8.880	68.9
2014	90.3	$606.0	$9.238	65.6
2015	110.3	$606.4	$9.612	63.1
2016	130.3	$610.9	$10.000	61.1
			Learning Rate:	87.4%
			Theoretical First Unit Hours:	157.2

Escalation Index 1 below was derived from the recorded Hourly Labor Rates so that it would perfectly describe price escalation for this program's labor rates. When the escalation rate used for normalization removes exactly the full rates of inflation and real price change, the only remaining cost drivers become quantity and quality changes (see Chapter 3 for the Cost Estimator's Framework). Assuming that this estimate is for a constant-quality product, the resulting Cost Improvement Curve has the same coefficients as the Learning Curve, and produces the same TY$ estimate.

Table 2. Cost Improvement Curve: Hours per unit are not known, multiple indices available to normalize costs.

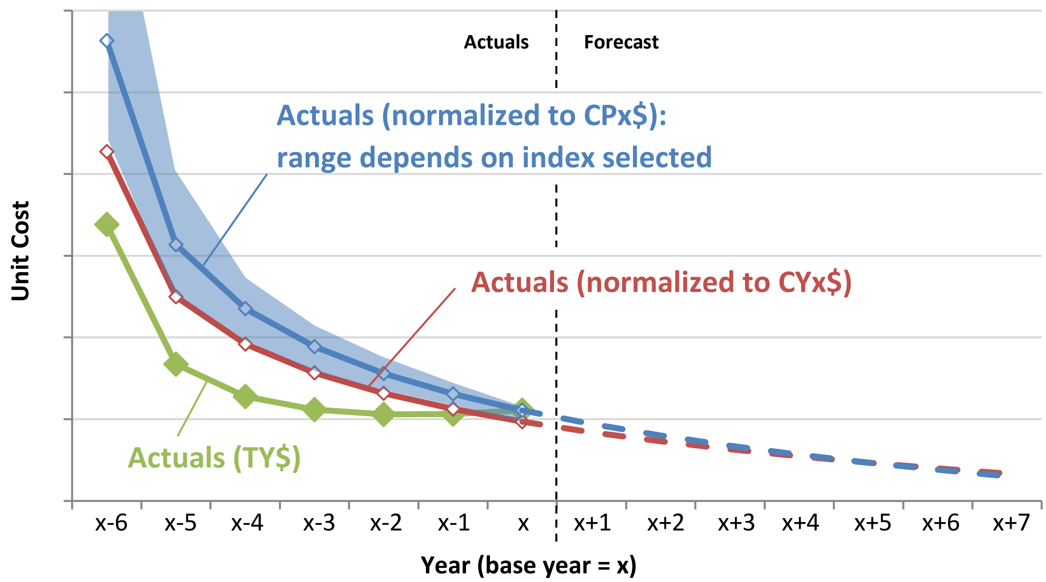
Year	Cumulative Quantity (Midpoint)	Avg. Unit Cost (TY$)	Inflation Index	Avg. Unit Cost (CY16$ = TY$/Inflation Index)	Escalation Index 1	Avg. Unit Cost (CP16$ = TY$/Escalation Index 1)	Escalation Index 2	Avg. Unit Cost (CP16$ = TY$/Escalation Index 2)
2010	7.50	$838.3	0.8880	$944.0	0.7885	$1,063.2	0.7050	$1,189.1
2011	29.70	$667.4	0.9057	$736.9	0.8203	$813.6	0.7473	$893.1
2012	50.00	$627.7	0.9238	$679.5	0.8535	$735.4	0.7921	$792.5
2013	70.20	$611.6	0.9423	$649.1	0.8880	$688.7	0.8396	$728.4
2014	90.30	$606.0	0.9612	$630.5	0.9238	$656.0	0.8900	$680.9
2015	110.30	$606.4	0.9804	$618.5	0.9612	$630.9	0.9434	$642.8
2016	130.30	$610.9	1.0000	$610.9	1.0000	$610.9	1.0000	$610.9
			Cost Improvement Rate:	89.9%		87.4%		85.2%
			Theoretical First Unit Cost:	$1,295		$1,572		$1,886

In most cases, if you are using a Cost Improvement Curve, you either do not have enough information to complete a Learning Curve or you do not want to use labor hours alone to model future costs. In these cases, you will not likely know the "perfect" escalation index to produce a CP$, and may have multiple options for how to normalize the TY$ costs to CP$ for regression.

There are two primary takeaways from the example in Figure 5-8. First, a CIC using CP$ that were normalized with a "perfect" escalation index, or one that completely describes the rate of escalation in the costs, produces the same slope and T_1 value (157.2 hours versus $1,572 at $10 per hour) as a learning curve (see Appendix E for graphs). Second, CICs produced in CP$ yield different slopes and T_1 values depending on the amount of escalation removed when normalizing the TY$ raw data; normalization for larger positive rates or smaller negative rates produces CICs with steeper slopes and higher T_1 values compared to normalization for smaller positive rates or larger negative ones. This fact highlights the importance of selecting appropriate escalation indices as described in Chapters 3 and 6, as you will often have to choose among multiple escalation indices in real-world applications.

The graph in Figure 5-9 is a generalized visualization of the concepts described above, showing the various options for normalizing TY$ data to build a CIC. In this picture, the year "x" is the last year of actuals available, and all historical data points are normalized to that base year. There is only one option for normalizing the TY$ data to CY$ (red) because there is only one rate of inflation, but multiple options for normalizing the data to CP$ (blue).[24] The CP$ line in the middle of the blue range represents the "perfect" CP$ CIC that perfectly matches a learning curve that captures the labor hours directly.

Figure 5-9. Cost improvement curves in CY$ vs. CP$



As you can see, the shape of the CIC (and therefore its coefficients for the slope and first-unit costs) depend on the index selected for normalization. There is only one line for CY$ because there is one rate of inflation for all commodities, but the shaded area around the CP$ line reflects the variability of curves that could result from using different escalation indices to produce CP$. You should use your best judgment in selecting an escalation index that reflects the economic circumstances of the cost element in question, and may wish to try fitting the curve with a couple of different relevant indices to determine how sensitive your results are to index selection.

Although the lines appear to converge in Figure 5-9 regardless of the index used for normalization, one is in CY$ and the other is in CP$, and they must both be converted to TY$ for direct comparison and to report the total TY$ estimate values. To convert to TY$, you would apply forecasted inflation to each point on the CY$ curve, and you would apply forecasted escalation to each point on the CP$ curve. Assuming escalation is greater than inflation (i.e., real price change is positive), you would see a diverging trend like the one in Figure 5-10 below. The forecasted TY$ costs would be higher using the CP$ CIC than using the CY$ CIC because the CY$ version neglects future real price

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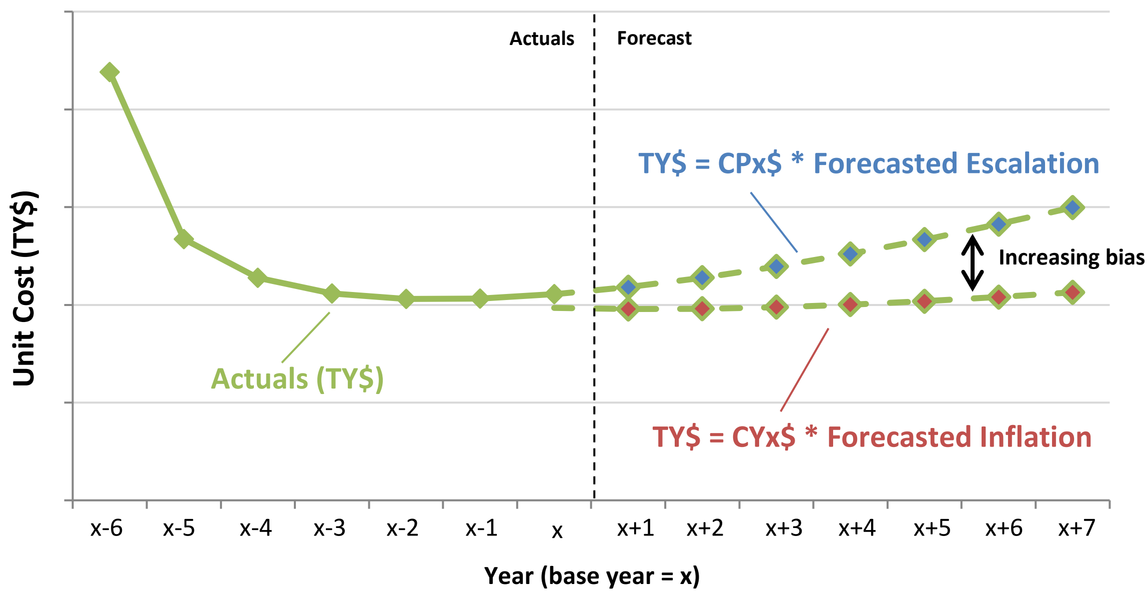
[24] The blue area shown may in fact be wider, even cutting into the area between the CY$ and TY$ lines or below the TY$ line if real price change is negative. The area shown here assumes that real price change is positive, though that is not always the case. See Appendix C for more information.

change. The difference between the two models (or between two CP$ models developed using different escalation indices) depends on the time period and difference in forecasted price change rates.

Figure 5-10. CICs developed using CY$ underestimate future costs when real price change is positive.



The use of CP$ in cost improvement curves seeks to strip away noise in the change of the dollar's purchasing power relative to the proper object of learning curve analysis, labor hours. Because information regarding past and future escalation rates is often noisy itself, it is recommended that cost estimators seek to use effort (labor hours) data whenever possible for estimating learning curves. If you obtained a perfect, quality-adjusted escalation index to normalize the data for a CP$ cost improvement curve (which is likely hard to find), it would provide the same results as a learning curve built on labor hours. A cost improvement curve in CP$ is a second-best method when only costs (dollars) are available and labor costs can be targeted. See Appendix E for an extended example.

4. "Why can't I do these calculations in CY$ or TY$?"

The above sections showed that cost estimating formulas will produce different results when developed with inputs in different dollar types, so you may be wondering why developing them in CP$ is not just different, but preferred. After all, you can build equations using any kind of numbers, and you may think that you could get a valid result as long as you use compatible numbers throughout (e.g., use TY$ as an input to an equation designed for TY$). However, formulas built using TY$ or CY$ inherently build in some amount of escalation or real price change, respectively, that occurred between historical data points, which is unlikely to be perfectly replicated in the future.

For example, the CY$ CER in Figure 5-5 included data points from 1990 to 2005, and those points experienced some amount of real price change relative to each other during that time. If you wanted to use that CER to predict the CY$ cost of a unit purchased in 2025 based on weight, you would have to assume that wherever the future program's weight fell on the y-axis, the x-coordinate on the CER line would automatically include the exact amount of real price change that occurred between the base year of the CER and the program's transaction year. This result is not probable, as no point on the CER included real price change that may have occurred after 2005, and each point represents a varying amount of real price change relative to the base year of the equation. If the CER had been built in CP$ instead, it would have removed this correlation of cost with time.

Normalizing input data prior to performing calculations is not a new concept, but the idea of using CP$ rather than CY$ may be new to many readers of this handbook. If you are still uncomfortable with the distinction, consider the fundamental reason for normalizing data in this context: to enable direct comparisons without distortions due to timing. If it made sense to remove inflation for this purpose when you first learned cost estimating (likely prior to the publication of this handbook), it should make even more sense to remove escalation. Removing inflation would only achieve part of the goal of removing timing-induced distortions in costs.

5. "Can I still use an old CER that was built in CY$?"

The previous sections argue for using CP$ in CERs, but you may still wish to use CY$ equations that your organization endorsed prior to the publication of this handbook. You should consider rebuilding the analysis in CP$ if it is practical to do so; however, continued use of CY$ equations is permissible in cases where zero real price change for all data points during the historical period is a defensible assumption. If you determine that the assumption of zero real price change is defensible, you should include your reasoning in your estimate documentation. You should also treat the output of any such CER as a CP$ value, and apply the full rate of forecasted escalation to reach TY$ in subsequent steps (in accordance with the diagram in Figure 5-2).

C. Output types for external reports, including budgets and other decision making (TY$ obs and CY$ obs)

Although you should perform most cost estimating calculations in CP$ as described in the previous section, you should generally not present CP$ results to decision makers—they may lack the context to fully understand what CP$ represent for any given cost element (see Chapter 8 section C for more information). Constant prices have no real-world significance because prices generally do not remain constant over extended periods, and the indices that produce them may reflect highly specialized economic sectors with which decision makers are not familiar. For example, a cost estimate for aircraft production that uses an aircraft-specific index to report CP$ would be stating the costs relative to the aircraft industry, and a decision maker would have to be familiar with the pricing trends of the aircraft industry (which could be measured in many different ways depending on the index selected) to make sense of the CP$ costs. Rather, cost estimate outputs for presentation to decision makers should be in TY$ obs and CY$ obs.

The case for reporting cost estimate results in TY$ obs is fairly obvious: TY$ costs represent the actual amount of money that must be available at the time of future transactions, and Federal budgeting deals with obligations that are outlaid over extended periods. Reporting costs in CY$ obs provides an added point of comparison for those costs relative to the economy, which is useful for several reasons. First, it is a common point of comparison for all programs, and there is no ambiguity in the type of index applied to generate the numbers (inflation only). Second, decision makers from any organization including DoD, Congress, and others can generally relate to broad economic trends, and do not require detailed knowledge of the price trends in particular industries to contextualize the results.

Third, overall economic trends typically drive the total size of the Federal budget and the DoD budget by extension, so normalizing program costs and the budget to CY$ obs for tradeoff and trend analyses provides a view of the program relative to a constant budget level. Fourth, and perhaps most importantly, costs presented in CY$ obs preserve the appearance of commodity-specific real price change, which can have significant implications for the long-term affordability of programs. Presenting costs in CP$ would remove that real price change, and any decisions regarding the program might be at risk if costs grow faster than inflation.

D. Use of TY$ exp and CY$ exp as outputs

TY$ exp and, by extension, CY$ exp are not typically appropriate output types for presenting cost estimate results because they are not compatible with obligations-oriented DoD budgets, or analyses thereof. TY$ exp and CY$ exp are also not appropriate inputs to calculations such as average cost factors, CERs, and CICs for the reasons discussed in section B of this chapter. However, TY$ exp are a common input type for cost estimates (e.g., CSDR data), so you may wish to include TY$ exp or CY$ exp in briefings or other supporting documentation when in-depth discussions of an estimate's source data are required. Any materials presenting TY$ exp or CY$ exp should be clearly labeled as such, per the documentation instructions in Chapter 9.

6. Choosing an Index

Based on your characterization of each input and output as described in the previous two chapters, you must choose appropriate inflation or escalation indices to convert the inputs to outputs. This chapter will describe the analytical decisions required to select an index: some are automatic based on the conversion you are executing, whereas others will depend on the commodity you are estimating, information available, and time permitted for analysis. The questions you must answer are:

A. What kind of price change is the conversion meant to capture?

B. What indices are available for the commodities involved, and which is most appropriate?

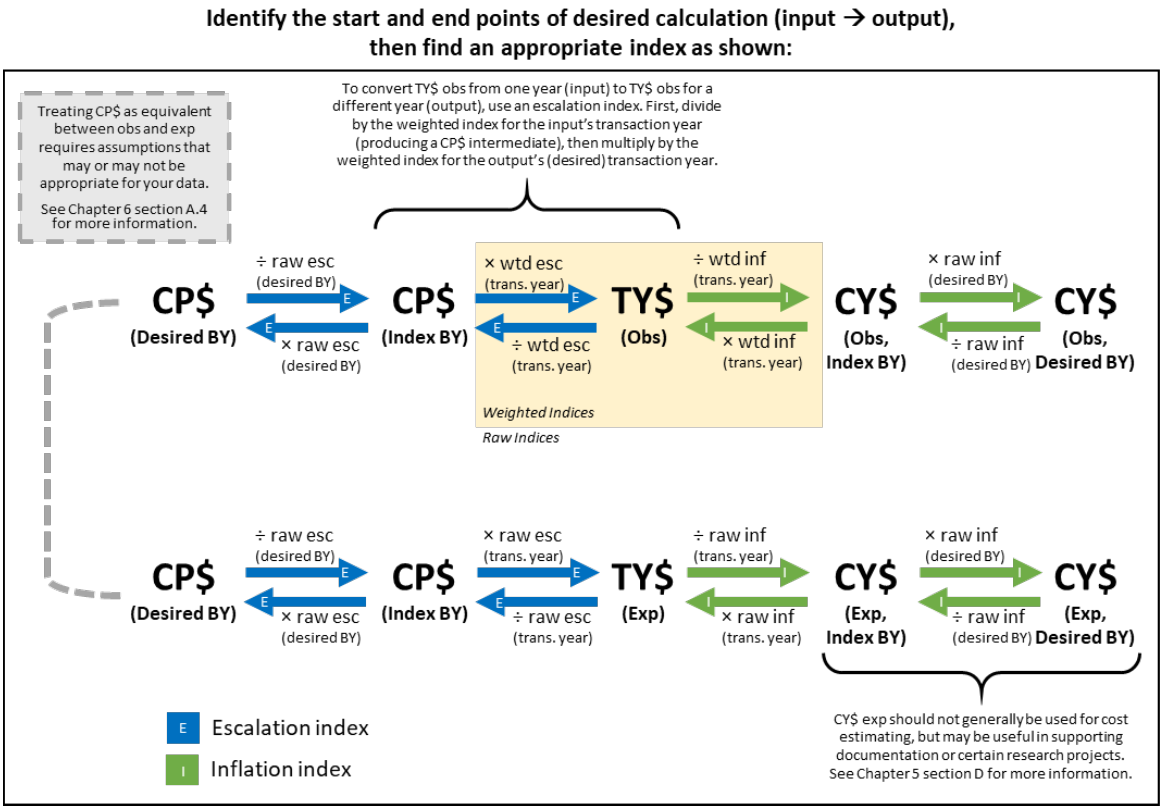
C. Does either the input or output have outlays?

D. Does the index include all years required?

The following sections will address each of these questions. Also see Figure 6-1 below for a quick-reference guide.

To use Figure 6-1, locate the input type and desired output type as determined using the instructions in the previous two chapters. The arrows joining two points identify the type of index required; for example, if your input is TY$ obs and you need an output in CY$ obs, Figure 6-1 shows that you need to divide the TY$ obs input by a weighted inflation index (and the result will be CY$ obs in the base year of the inflation index). The text in this chapter will help you understand the indices you find to make sure they are the correct kind for your desired conversions, and Chapter 7 will help you perform the calculations. Choosing an index of a different type than that annotated in Figure 6-1 will produce incorrect results, as discussed in Chapter 8 section A. Consult your agency's best practices when selecting indices to promote consistency and facilitate estimate reviews, but verify that any agency-recommended indices are in fact appropriate for your particular estimate.

Figure 6-1. Flowchart for selecting an index ("Nunchuck Chart").



A. What kind of price change is the conversion meant to capture?

Based on the determination of input type and output type, Figure 6-1 shows whether you should use an inflation index, escalation index, or both for the desired conversion. The following sections describe these scenarios in detail.

1. Inflation

Most DoD-published indices measure inflation only—they are equivalent to the GDPPI, and capture no commodity-specific price change.[25] This fact is somewhat obscured by the commodity-specific names applied to DoD-published indices, such as Research, Development, Test, and Evaluation (RDT&E) and Aircraft Procurement, but in fact they do not reflect DoD pricing experience or industry analysis for those commodities. Instead, these names stem from the application of appropriation-specific

[25] Notable exceptions include indices for military pay, civilian pay, fuel, and medical expenses.

outlay profiles in the weighted versions of the indices (more on this in section C), and it is important to note that most account for only inflation.[26]

2. Escalation

The DoD publishes several escalation indices that describe the net effect of all price change forces on the commodities described. The following indices apply to all Services, but also see Appendix B for a list of Service-specific escalation indices.

- Military pay
- Civilian pay
- Fuel
- Medical expenses

Although most DoD-published indices capture only inflation, you may still use them to describe escalation if you can defend the assumption that the commodity being estimated experiences no real price change (i.e., escalation equals inflation). Doing so may be appropriate for estimating costs for generic goods or services that can be reasonably assumed to fluctuate at a rate comparable to that of the entire economy, but likely inappropriate for unique defense items that represent a small, specialized portion of the economy. For most commodities represented in your estimate, you should explore options other than the GDPPI or DoD-provided indices to capture the full rate of escalation. See Appendix B for more information, including a list of options such as:

- Professional market studies
- Government-published price indices
- Contractors' forward pricing rate agreements
- Contractual economic adjustments
- Historical cost trends
- Historical labor rates

3. Within-type conversions (CY-CY, CP-CP, TY-TY)

Changing the base year of a CY$ (e.g., CY08$ to CY17$) or a CP$ is more of an administrative task than an analytical one. Such conversions are primarily used to facilitate comparisons across analyses. For example, you may wish to compare unit costs for multiple weapon systems whose Acquisition Program Baselines (APBs) were codified in different base years. Although all of the costs in this APB scenario would have been normalized to CY$ (see Figure 5-1), they were measured in inconsistent dollar values (i.e., normalized to different points in time). The same would be true for CP-CP

[26] Analysts can confirm whether an index is inflation-only by comparing the raw version to the GDPPI. If the indices are equal for all years, the index of interest captures only inflation. If the comparison reveals differences, it must be capturing other forms of price change.

conversions, such as to compare FPRAs released by a contractor at different times. When changing the base year of an input that is CY$ or CP$, you must use the same exact index as was used to produce the input when possible. See Chapter 8 section B for a discussion of the bias that can be introduced when using a mismatched index in this case.

Unlike CY-CY and CP-CP conversions that are more administrative in nature, TY-TY conversions can be an essential analytical tool for forecasting costs. The most common use of this process would be when using a single value, such as a subject matter expert's input or single-year contract value, which you expect to recur in a later year (e.g., one-time recurrence, annually, bi-annually, etc.) at a future value that has changed at the rate of a particular escalation index.

4. Assumptions required for "conversions" between obligations and expenditures

Obligations and expenditures are inherently different measures of financial activity: obligations include predictions about future spending patterns (via outlay profiles), whereas expenditures capture actual disbursements. Any attempt to "convert" one to the other requires assumptions about the accuracy of an obligation's outlay profile. Consider the following examples.

A program office obligates $100M in FY21 for an effort to be performed from FY21-23. They based their $100M estimate on the total workload, anticipated price escalation over the period of performance, and the assumption that the spending pattern for the effort would reflect the historical average for similar efforts: 40% the first year, 45% the second year, and 15% the third year. The program office therefore expects the effort's annual expenditures to be $40M in FY21, $45M in FY22, and $15M in FY23. This process of "converting" obligations to expenditures is valid, but is based on the assumption that the predicted workload, escalation rate, and outlay profile built into the original $100M obligation are all accurate. However, those inputs are likely to change: workload could move from one year to another (when prices could be different), or actual escalation rates may vary. The program office could obligate additional funds or de-obligate excess funds over the course of the effort in response. A comparison of the original $100M obligation to the actual expenditures when the effort is complete is likely to show a delta at the annual or total level (e.g., $100M originally obligated, $102M expended if costs exceeded the original estimate by $2M) that cannot be accounted for via indices as discussed in this chapter.

Conversely, say you are using TY$ exp data from an analogous program's CSDRs as inputs to a new cost estimate. You graph the actual cost of work performed over time and can calculate the percent of funds expended in each year of the period of performance. When you compare this rate of expenditure to the standard outlay profile for the appropriation that funded the contract, you discover that they are not the same—the outlay pattern for this contract did not reflect historical averages for similar efforts.

You may decide to assume that all funds that were eventually expended for the contract were obligated at the time of contract award, and based on the standard outlay profile published at the time—this procedure effectively "converts" the TY$ exp from the CSDR data into a TY$ obs amount in the year of contract award. However, this "conversion" builds in the difference between predicted outlay profile and actual expenditure pattern, and any further calculations will be slightly distorted as described in Chapter 8 section B (first two examples).

The examples in this section show that there is a predicted-versus-actual element to the difference between TY$ obs and TY$ exp. Unlike other conversions discussed in this chapter, a "conversion" between TY$ obs and TY$ exp requires you to make assumptions about how accurately an obligation predicted the eventual expenditure. A "conversion" from TY$ obs to TY$ exp is like saying, "if I have accurately estimated future escalation and the outlay profile perfectly predicts spending patterns, my obligated amount will equal the expended amount, and I will not need to change scope to stay within budget." Conversely, a "conversion" from TY$ exp to TY$ obs is like saying, "if I had known the actual escalation rate and spending profile at the time of obligation, this is the amount I would have obligated."

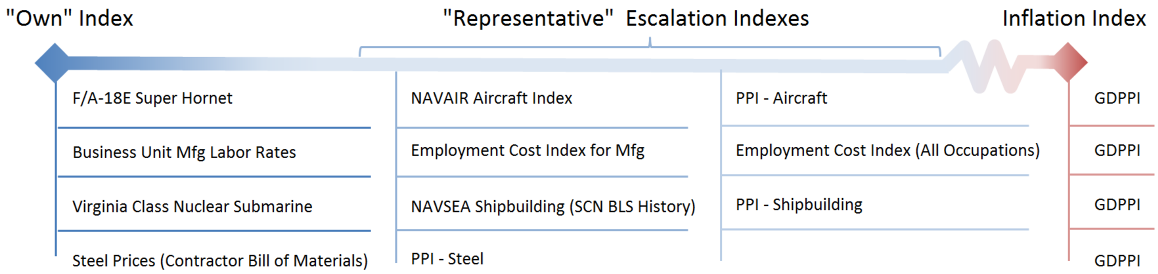
Anytime you use inputs that are based on expenditure data (including CP$ values normalized from TY$ exp inputs) in a cost estimate—the results of which you will present in TY$ obs and CY$ obs—you will have to cross Figure 6-1 (the "nunchuck chart") from the bottom row (expenditures nunchuck) to the top row (obligations nunchuck). This is possible treating their escalation-normalized values (in CP$, with not outlays) as equivalent.

B. What indices are available for the commodity involved, and which is most appropriate?

Though inflation will affect all cost elements regardless of the level of detail, you may assess real price change and overall escalation at whatever level of the WBS makes sense given time constraints and the ability to find indices at different levels. For example, you may choose an index that represents a complete weapon system and apply it at the total level, you may choose multiple indices that represent components within the weapon system, or you may choose indices for specific raw materials and labor categories represented in the estimate.

Figure 6-2 below depicts the spectrum of detail available in indices, which range in specificity from an "own" index developed from program-specific inputs for use within its own estimate, to "representative" escalation indices that are commodity- or industry-specific, to the most general "inflation" index available for the entire economy (GDPPI or GDP Deflator). You are responsible for isolating cost categories with different price change rates within your estimate, and matching them up with appropriate indices (or making your own if desired).

Figure 6-2. Spectrum of price indices.



In selecting an index, note that relying on an index name is insufficient to determine the true relevance of the underlying data to your estimate. The name of an index may not reveal what types of price change are included (e.g., inflation only, labor only, etc.), and may include multiple cost types (e.g., labor and materials) with different content or proportions than present in your data.[27] Understanding the underlying features of an index—beyond the name—is important to determine whether you need to include additional sources of price change, or deconflict between indices that would double-count certain price change effects. For example, contract labor rates may be a factor in both market-specific pricing and FPRAs, so you wouldn't want to apply both types of indices to a single cost element.

C. Does either the input or output have outlays?

After selecting an index on the basis of the type of price change included (i.e., inflation or escalation) and content (e.g., weapon system level, subsystem level, labor or materials), you must also determine whether the index should include outlays. Indices that include outlay profiles are "weighted indices," while those that do not are "raw indices."[28] Chapter 7 section E includes instructions for creating weighted indices.

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[27] There are several "composite" indices published in DoD sources that combine indices for military pay, civilian pay, fuel, and purchases into a single index. The use of these composites can yield results inconsistent with the terminology presented in this guide, because the index is a hybrid of inflation-only (purchases) and escalation (pay and fuel) indices, and thus can produce an output that is a hybrid of CY$ and CP$. These indices should be used only with extreme caution to ensure results are properly interpreted and labeled, and should not be used to generate official program baselines meant to be in pure CY$. If you must use one of these hybrid indices, you should treat it as an escalation index (this method assumes no real price change on the portion of the index that is based on inflation indices).

[28] Composite indices may be comprised of both raw and weighted indices depending on how they were created. Composite indices that include any effect of outlays, even on only a portion of the index,

Outlays account for the fact that some types of costs are not fully expended in the year in which they are labeled in a cost estimate. For example, an organization is provided a certain amount of funding in its Operations and Maintenance (O&M) account each fiscal year. These O&M funds must either be obligated by the end of the fiscal year or returned to the Treasury. While the funds must be obligated in that fiscal year, the funds do not have to be outlaid (i.e., leave the Treasury) within the fiscal year. The outlay can, and many times does, occur after the close of the fiscal year.

DoD analysts produce and use indices that are weighted using outlay profiles to reflect commodity-specific patterns in expenditure timing.[29] The Under Secretary of Defense (Comptroller) publishes outlay rates for all DoD appropriations by examining historical outlay rates, then determining the percentage outlaid in the year the funding was appropriated and in each subsequent year. The application of these outlay profile multipliers to the GDPPI creates most DoD-published indices, which remain inflation indices even after outlay profiles are applied.[30] Individual cost analysts and agencies may also apply these standard outlay rates to raw escalation indices from external sources (e.g., Producer Price Indices, National Reconnaissance Office indices), which were not produced with the spending profiles of DoD appropriations in mind.

TY$ obs include escalation during the outlay period (see Chapter 2 section D), and CY$ obs include real price change during the outlay period (see Chapter 2 section E). Outlays are not present in TY$ exp, CY$ exp, or CP$. Only conversions to or from TY$ obs require weighted indices—all other conversions require raw indices.

D. Does the index include all years required?

Indices vary in the length of time over which they measure price changes. Most DoD-provided indices include index values for many decades' worth of history, but only extend through the current FYDP or include one additional year beyond it (e.g., indices published in 2020 may not extend beyond 2024 or 2025). Because many program estimates have requirements beyond the FYDP, analysts must usually apply long-term assumptions to extend the index to cover all years required.

While professional forecasts are preferred, you will at times need to develop your own to cover all years in your estimate. To do so, you will have to select an annual rate of

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should be treated as weighted indices. See previous footnote on exercising caution when using composite indices.

[29] Appropriations that are expended entirely during the year of obligation, such as military pay, civilian pay, and fuel (i.e., "one-year money"), have outlay profiles of 100% in the first year. In these cases, the raw and weighted indices are the same.

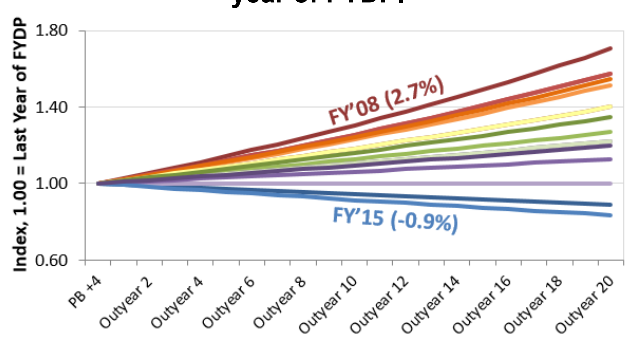
[30] If you believe that funds will be expended in a different outlay pattern than that represented by any DoD index, you may develop a custom outlay profile and use it to create a custom weighted index. See Chapter 7 section E for more information on building a weighted index.

change to apply to the years beyond the scope of the index, and should choose those rates with the goal of optimizing the realism and stability of the estimate. There is no "right way" to forecast a price index; one option is to use a line-of-best-fit from historical data, or another is to carry forward the average rate from completed years. See Chapter 7 section D for detailed instructions on how to extend an index to future years.

Another alternative is the risky but common practice of applying the annual rate of change from the last year of the FYDP to all subsequent years. For example, if the forecasted escalation rate for the fuel appropriation in the fifth and final year of the FYDP were 1.00 percent, you could (but perhaps should not) assume annual 1.00 percent escalation for fuel in the sixth, seventh, and eighth years, and beyond. Neither the Office of Management and Budget nor OUSD (Comptroller) currently require analysts to extrapolate price change assumptions for the last year of the FYDP into out-years beyond the scope of the guidance. This practice may cause disruptive changes in cost estimates that are updated annually, based solely on updating forecasted values that have a fair amount of uncertainty. Cost analysis organizations should consider whether changing post-FYDP escalation rates frequently leads to sufficient improvements in estimate accuracy to justify this "whiplash" effect on total costs.

Estimates that span long periods of time (such as sustainment) and estimates for commodities with volatile prices (such as fuel) are particularly vulnerable to even small fluctuations in index values. For example, between fiscal years 2001 and 2016, the fuel escalation rate in the last FYDP year ranged between -0.9 percent and 2.7 percent. Extrapolation of these rates over a twenty year window, shown in Figure 6-3, can create substantially different conclusions about future price levels. Similarly, a later example in Figure 8-3 shows that the use of different escalation rates—whether from using a different index source or indices representing different cost content—drives larger estimate deltas over long periods of time.

Figure 6-3. Extrapolating fuel prices using last year of FYDP.



7. Calculations and Examples

Inflation and escalation calculations require three major components: input, output, and index. The previous chapters described in detail the processes required to understand these components and treat them correctly in calculations—this chapter will describe the calculations themselves. The first section contains general instructions for converting inputs to outputs, and later sections describe additional calculations that may be required in certain cases.

A. General instructions

Follow this checklist to complete generic calculations for inflation and escalation, and refer to previous chapters as needed to ensure your inputs and outputs are classified correctly. Some parameters (in *italics*) may need additional preparation before you can use them, as described in later sections.

1. Identify *Input* value.
2. Identify input value type (TY$ obs, TY$ exp, CY$ obs, CY$ exp, or CP$). See Chapter 4 for detailed instructions.
3. Identify fiscal year of the input cost ($Year_{in}$). The input value may represent a single fiscal year (i.e., obligated in a single year, expended in a single year, or normalized relative to a single year), or it may represent multiple fiscal years (e.g., contract costs over a three-year period, or contract costs over an eight-month period that crosses fiscal years).
    a. If the input value spans multiple fiscal years, you must select a single fiscal year to represent the value in further calculations. See section B below for further instructions.
    b. For TY$ inputs, $Year_{in}$ is the transaction year. For CY$ and CP$ inputs, $Year_{in}$ is the base year (e.g., an FY21 cost normalized to CY18$ has a $Year_{in}$ of 2018).
4. Select desired output type (TY$ obs, TY$ exp, CY$ obs, CY$ exp, or CP$). See Chapter 5 for detailed instructions.
5. Identify desired fiscal year of output value ($Year_{out}$). For TY$ outputs, $Year_{out}$ is the transaction year. For CY$ and CP$ outputs, $Year_{out}$ is the base year.
6. Select an index that is appropriate for the type(s) of good(s) and/or service(s) included in the input value (e.g., aircraft procurement, operations and

maintenance, steel, etc.), and for the type of conversion to be executed (i.e., escalation or inflation). See Chapter 6 for detailed instructions.

a. Identify the index value ($Index_{in}$) for $Year_{in}$ as determined in step 3. If the input value is TY$ obs, make sure to use a weighted index; otherwise, use a raw index.

b. Identify the index value ($Index_{out}$) for $Year_{out}$ as determined in step 5. If the output value is TY$ obs, make sure to use a weighted index; otherwise, use a raw index.

7. Multiply the *Input* by $Index_{out}$ and divide by $Index_{in}$ to calculate the *Output*:

$$Input * \frac{Index_{out}}{Index_{in}} = Output$$

…where $Index_{in}$ and $Index_{out}$ are functions of the dollar types, years, and qualitative content (i.e., good(s) and/or service(s) represented) of the input and output, respectively, as described above.

8. Label your results clearly so other analysts can follow these instructions and obtain the same result. See Chapter 9 for best practices in documenting inflation and escalation calculations.

If you are completing these calculations as part of a dynamic cost model (as opposed to a quick-turn calculation for only a few inputs), you should consider modeling methods that will allow you to apply this process simultaneously to many inputs, across many years, and using multiple indices. For example, the VLOOKUP, INDEX, and MATCH functions in Microsoft Excel can automatically identify the relevant values in indices based on a selected index name and year across your model. You should also consider modeling techniques that will allow you to change selected indices, desired base years (for CY$ and CP$ outputs), and any other parameters for which you made decisions so that you can change them easily at any time.

B. Working with multi-year or cross-year input values

You may occasionally work with input values that span multiple years, and therefore have multiple options for the $Year_{in}$ parameter described in the instructions above. For example:

- Total FYDP Budget (FY16-20) = $X: these are TY$ obs spread over a five-year period.[31]

[31] Note that, for the purposes of this section, an obligation in a given year is not considered a "multi-year cost." Although an obligation will be expended over multiple years, there is no ambiguity in the year to which costs are assigned. You will use the year of obligation as $Year_{in}$ for subsequent calculations, and

- Total contract value (FY18-20) = $X: these are TY$ exp spread over a three-year period.
- Total life cycle cost estimate (FY11-20) = $X: these costs may be any value type (see data label in estimate, if available) spread over a 10-year period.

Ideally, when dealing with inputs such as those in the examples above, you will be able to find an alternative data source that breaks out the multi-year costs into individual years. If you are unable to obtain annual data, you will need additional data sources to better characterize the timing of costs during the multi-year period for further calculations. Without this additional step, there is no clear way to align the costs with indices since indices typically measure annual or quarterly rates of change.

Some data that may help you understand the timing of costs within a multi-year range include labor hours, material invoices, earned value management data sources (e.g., Contractor Performance Reports [CPRs]), Cost and Software Data Reports (CSDRs), appropriation-specific outlay profiles, and subject matter expert opinion. You can convert these types of data into distributions with which to allocate the multi-year costs to individual years within the range, or, especially when using qualitative phasing data such as subject matter expert opinion, to a single year (e.g., "assign 100 percent of costs to the midpoint year of the range").

It is always better to obtain annual cost data rather than using an allocation method, as any assumed phasing profile may assign some costs to years in which they did not or will not occur. Any further calculations to convert those misaligned costs to different types of dollars or different base years will capture more or less price change than intended.

Figure 7-1 below shows how you can obtain different results when normalizing data based on the phasing profile chosen to allocate a multi-year cost to individual years. In this example, a contract spanning FY18-20 is treated as a TY$ exp; the analyst identified five possible phasing profiles[32] relevant to the contract, allocated the total cost to individual years using each profile, and then converted each year's cost to CY15$ exp.

the use of a weighted index (when appropriate) will automatically adjust for the fact that funds will actually be expended over multiple years.

[32] In reality, you are unlikely to find such a wide variety of phasing profiles for a single cost input. The profiles shown here simply demonstrate some of the patterns you may observe in phasing profiles, and show the potential for distortion if you select a phasing profile that does not closely reflect the actual (though unknown) phasing profile.

Figure 7-1. Example: Applying phasing profiles to multi-year costs.

Task: Given a $100,000 contract expended from FY18-20, convert contract cost to CY15$.

$$TY_{exp,phasing\ year} * \frac{Index_{2015} = 1}{Index_{phasing\ year}} = CY15\$$$

	Inflation Index *(Notional)*
2015	1.00000
2016	1.02000
2017	1.04040
2018	1.06121
2019	1.08243
2020	1.10408

The input (contract cost) does not have an index value directly associated with it because it spans multiple years. You must determine how much of the total cost was spent in each year (FY18, FY19, and FY20), then convert each year's costs (TY$ expenditures, as provided) to CY15$ using the index above.

The table at right shows five possible options for allocating the total cost to individual years. Data such as these could be obtained from many available sources, such as labor hours, material invoices, outlay profiles, etc., and converted to percentages if necessary. The sources of this sample data are not specified, and are for illustrative purposes only.

Notice the differences in results depending on the phasing profile selected. You should research the phasing applicable to your estimate to obtain a representative allocation of costs.

		TY$ Phasing		Index		CY15$
Possible Phasing Profile #1 (midpoint year)	FY18 =	$ 0	/	1.06121	=	$0
	FY19 =	$ 100,000	/	1.08243	=	$92,385
	FY20 =	$ 0	/	1.10408	=	$0
				Total CY15$	=	*$92,385*
Possible Phasing Profile #2 (front-loaded)	FY18 =	$ 60,000	/	1.06121	=	$56,539
	FY19 =	$ 30,000	/	1.08243	=	$27,715
	FY20 =	$ 10,000	/	1.10408	=	$9,057
				Total CY15$	=	*$93,312*
Possible Phasing Profile #3 (back-loaded)	FY18 =	$ 10,000	/	1.06121	=	$9,423
	FY19 =	$ 30,000	/	1.08243	=	$27,715
	FY20 =	$ 60,000	/	1.10408	=	$54,344
				Total CY15$	=	*$91,482*
Possible Phasing Profile #4 (normal dist.)	FY18 =	$ 15,000	/	1.06121	=	$14,135
	FY19 =	$ 70,000	/	1.08243	=	$64,669
	FY20 =	$ 15,000	/	1.10408	=	$13,586
				Total CY15$	=	*$92,390*
Possible Phasing Profile #5 (uniform dist.)	FY18 =	$ 33,000	/	1.06121	=	$31,097
	FY19 =	$ 34,000	/	1.08243	=	$31,411
	FY20 =	$ 33,000	/	1.10408	=	$29,889
				Total CY15$	=	*$92,396*

The different results for each phasing option in Figure 7-1 show that a poor selection of phasing profile can distort the results of calculations. For example, if you chose Profile #2 and later discovered that the costs more closely followed Profile #3, your CY15$ result would be overstated by two percent. The magnitude of this distortion depends on the relationships among the allocation year, the true distribution of costs over time, and the rate of change. You should attempt to characterize cost profiles as accurately as possible, and recognize the potential impact of any uncertainty in your phasing assumptions.

The allocation method described above can also serve as a template when adjusting for differences in accounting systems, particularly for contract data. For example, even a 12-month contract may not align perfectly with the government fiscal year (GFY), such as a contract with a period of performance from 7/1/2019 to 6/30/2020. The expenditures represented on any final cost reports for this contract would not align with indices designed for the GFY (such as those provided by DoD sources) or calendar year (provided by external sources), so you may wish to treat the costs occurring in different time periods with different indices. If you wish to use an index aligned to the GFY, you should attempt to distinguish the contract's costs occurring from 7/1/2019 to 9/30/2019 from those occurring from 10/1/2019 to 6/30/2020, and use index values with a $Year_{in}$ of 2019 for the former and 2020 for the latter. If you wish to use an index aligned to the calendar year, you should instead separate the costs at the boundary of the calendar year (in this example: 7/1/2019 to 12/31/2019 costs have a $Year_{in}$ of 2019, and 1/1/2020 to 6/30/2020 costs have a $Year_{in}$ of 2020).

A final potential application of the allocation process described above is to "convert" obligations to expenditures. Obligations and expenditures are fundamentally different measures of then-year costs, so attempts to convert between them are not as straightforward as other calculations described in this handbook—they require analytical assumptions, not simple look-ups. However, if you assume that an appropriation-specific outlay profile will accurately reflect the expenditure rate for an obligation, you can use the outlay profile percentages to phase the obligation year's costs into the years in which funds are likely to be expended. You can also do the reverse, "converting" expenditures to assumed obligations by collapsing the expenditures down into the year in which they were most likely obligated, given typical outlay patterns. See Chapter 6 section A.5 for more information.

C. Basic sample calculations

This section shows some simple examples of inflation and escalation calculations. Given the notional indices provided, see the questions and answers at the end of this section for practice. Imagine that you obtained the following (notional) indices from a tool endorsed by your organization (left-side table of Figure 7-2). You observe that the base year of all of those indices is 2020, and that the GDP Price Index matches the raw indices for DoD RDT&E and DoD Aircraft Procurement, meaning that they represent inflation only (even though their names appear more customized). The raw Military Pay index is different from the GDP Price Index, meaning that it represents escalation for that commodity, and the weighted Military Pay index is the same as the raw, indicating that there are no outlays (i.e., the index represents one-year money). You also obtained an index from the Bureau of Labor Statistics (right-side table of Figure 7-2), which has a base year of 2015.

Figure 7-2. Indices for sample questions below.

(all indices notional)	GDP Price Index	DoD RDT&E		DoD Aircraft Procurement		Military Pay	
		Raw	Weighted	Raw	Weighted	Raw	Weighted
2015	0.9057	0.9057	0.9248	0.9057	0.9411	0.8626	0.8626
2016	0.9238	0.9238	0.9432	0.9238	0.9599	0.8885	0.8885
2017	0.9423	0.9423	0.9621	0.9423	0.9791	0.9151	0.9151
2018	0.9612	0.9612	0.9814	0.9612	0.9987	0.9426	0.9426
2019	0.9804	0.9804	1.0010	0.9804	1.0187	0.9709	0.9709
2020	1.0000	1.0000	1.0210	1.0000	1.0391	1.0000	1.0000
2021	1.0200	1.0200	1.0414	1.0200	1.0599	1.0300	1.0300
2022	1.0404	1.0404	1.0622	1.0404	1.0810	1.0609	1.0609
2023	1.0612	1.0612	1.0835	1.0612	1.1027	1.0927	1.0927
2024	1.0824	1.0824	1.1052	1.0824	1.1247	1.1255	1.1255
2025	1.1041	1.1041	1.1273	1.1041	1.1472	1.1593	1.1593
2026	1.1262	1.1262	1.1498	1.1262	1.1702	1.1941	1.1941
2027	1.1487	1.1487	1.1728	1.1487	1.1936	1.2299	1.2299
2028	1.1717	1.1717	1.1963	1.1717	1.2174	1.2668	1.2668
2029	1.1951	1.1951	1.2202	1.1951	1.2418	1.3048	1.3048
2030	1.2190	1.2190	1.2446	1.2190	1.2666	1.3439	1.3439

Commercial Aircraft Procurement (Bureau of Labor Statistics, BY=2015, *notional*)			
2015	1.0000	2031	1.4392
2016	1.0234	2032	1.4723
2017	1.0469	2033	1.5062
2018	1.0710	2034	1.5408
2019	1.0955	2035	1.5762
2020	1.1207	2036	1.6125
2021	1.1465	2037	1.6496
2022	1.1728	2038	1.6875
2023	1.1998	2039	1.7263
2024	1.2274	2040	1.7660
2025	1.2556	2041	1.8067
2026	1.2845	2042	1.8482
2027	1.3141	2043	1.8907
2028	1.3443	2044	1.9342
2029	1.3752	2045	1.9787
2030	1.4068	2046	2.0242

1. **Question:** Given a historical data point of $107M for RDT&E (obligated in 2017) on an analogous program, what would be the cost for similar work scope for an obligation in 2024?

   Observations: This is a TY$ obs to TY$ obs conversion. You will need a weighted index to go with the input, and another to go with the output. You will use the DoD RDT&E index provided because you believe it is a good match for the cost element content, even though it does not include real price change (i.e., you assume the cost element will experience zero real price change).

   Answer: $107M / 0.9621 * 1.1052 = $123M

2. **Question:** An analogous aircraft procurement program's CSDR data shows expenditures of $53,312 in 2016; $54,619 in 2017; and $55,872 in 2018. What were the average annual expenditures in 2020 dollars?

   Observations: The inputs are TY$ exp, so we will use a raw index first. However, the question is somewhat vague… what kind of "2020 dollars" should the output be, and what index will get us there? We know (from Chapter 5) that averages should be computed in CP$, so let's use the notional BLS Commercial Aircraft Procurement index (escalation) to produce a CP20$ output. The first step will convert each expenditure to CP15$ (with the base year of the index), and the second to CP20$ (with the desired base year).

   Answer:
   2016: $53,312 / 1.0234 = $52,093 (CP15$) * 1.1207 = $58,381 (CP20$)
   2017: $54,619 / 1.0469 = $52,172 (CP15$) * 1.1207 = $58,469 (CP20$)
   2018: $55,872 / 1.0710 = $52,168 (CP15$) * 1.1207 = $58,465 (CP20$)
   Sum (2016-2018, CP20$) = $175,315; Average = Sum / 3 = $58,438

Alternative Calculation: You could also calculate the average in CP15$ ($52,143) and convert that to CP20$ with the raw index for 2020:
Average (2016-2018) = $52,144 (CP15$) * 1.1207 = $58,438 (CP20$)

Further Observations: Notice that the CP20$ value for each transaction year is quite close to the average; this is a good indicator that the index selected (here, the BLS procurement option) was a good match for the trends observed in the historical data. If there were significant upward or downward trends remaining after normalizing to CP$, or if a step function or other pattern is observed, it may indicate that the index selected is not adequately capturing the price trends. In such a scenario, you may need to find another index or look for further ways to normalize your data (e.g., quantity changes).

3. **Question:** Given a military member's salary of $120,000 in FY 2020, what will the person's salary be in FY 2030, in TY$ and CY20$?

   Observations: We will disregard outlays for this example because military pay is one-year money,[33] so we will use only raw indices. Our input is TY$ (we can treat this as either obligations or expenditures due to the exclusion of outlays) because it represents a real-world transaction (payments to the employee). To convert our TY$ in 2020 to TY$ in 2030, we will escalate the value to TY$ for a future transaction year using the military pay index, then remove inflation from the result using the GDP Price Index to produce a CY20$ output (for the same transaction year).

   Answer:
   TY$ in 2030 = $120,000 * 1.3439 = $161,268
   CY20$ in 2030 = $161,268 / 1.2190 = $132,295

   Interpretation: What does the CY20 $132,295 result represent? If the 2030 salary has been normalized to a base year of 2020, why did we not get the same $120,000 salary for 2020 that we started with? The difference of $12,295 represents the real price change the salary experienced between 2020 and 2030; the person making $161,268 in 2030 would have the relative buying power *in 2030* of a person making $132,295 *in 2020*, <u>not</u> the same relative buying power as a person making $120,000 *in 2020*. This is where the difference between CY$ and CP$ comes into play; if we

[33] For some applications, military pay and civilian pay do exhibit outlay profiles to account for delays in benefits payments. For the purposes of this example, and to match the standard practice for many cost estimates, we will treat military pay as one-year money.

had converted the 2030 salary ($161,268) to CP20$ instead, we would have divided it by the same military pay index (1.3439) that produced it, yielding the familiar $120,000. These values mean different things and are useful for different analyses, as discussed in Chapter 5.

D. Making custom indices

You may want to use a particular escalation rate for which you cannot find an index, such as to match the average escalation rate observed in historical data or to conform to agency-wide best practices (e.g., "use X% compounding growth on top of inflation for depot level reparable prices").

For however many years you require in your index, determine the annual escalation rate. If your custom index is based on research into real price change rates alone, you may need to use the multiplicative relationship between inflation and real price change (as shown in Chapter 2 section C) to calculate the total rate of escalation for each year before proceeding. The rate may be the same for all years in your index, or you may use different rates in different years depending on how you believe prices will change over time. You must also decide whether to apply escalation linearly or in a compounding manner, as shown in Examples 1 and 2 below, or you may manually enter index values for other patterns of price change (e.g., step functions) as shown in Example 3. Each of the first two examples includes two options for calculating the index, one based on the number of years since the base year of the index (Method 1) and one that builds upon the previous year's index value (Method 2); you may only use Method 1 if you have a constant annual rate from the base year until the year for which you are calculating an index value.

Example 1. Element experiences 3.0% linear growth starting from FY21:

Index Year	Method 1 (blue = years since base year)	Method 2 (from previous index value)
FY21	= 1.0000 * (0.03 * 0) + 1 = 1.0000	= 1.0000
FY22	= 1.0000 * (0.03 * 1) + 1 = 1.0300	= 1.0000 + 0.03 = 1.0300
FY23	= 1.0000 * (0.03 * 2) + 1 = 1.0600	= 1.0300 + 0.03 = 1.0600
FY24	= 1.0000 * (0.03 * 3) + 1 = 1.0900	= 1.0600 + 0.03 = 1.0900
FY25	= 1.0000 * (0.03 * 4) + 1 = 1.1200	= 1.0900 + 0.03 = 1.1200

Example 2. Element experiences 3.0% compounding growth starting from FY21:

Index Year	Method 1 (blue = years since base year)	Method 2 (from previous index value)
FY21	= 1.0000 * $(1+0.03)^{0}$ = 1.0000	= 1.0000
FY22	= 1.0000 * $(1+0.03)^{1}$ = 1.0300	= 1.0000 * 1.03 = 1.0300
FY23	= 1.0000 * $(1+0.03)^{2}$ = 1.0609	= 1.0300 * 1.03 = 1.0609
FY24	= 1.0000 * $(1+0.03)^{3}$ = 1.0927	= 1.0609 * 1.03 = 1.0927
FY25	= 1.0000 * $(1+0.03)^{4}$ = 1.1255	= 1.0927 * 1.03 = 1.1255

Example 3. Element has negotiated fixed prices for FY21-23, followed by a one-time increase of 3.0% from the previous price, which will apply in FY24-25. Index patterns such as these can be entered manually:

Index Year	Index Value
FY21	= 1.0000
FY22	= 1.0000
FY23	= 1.0000
FY24	= 1.0300
FY25	= 1.0300

You may also make custom composite indices according to the instructions above, with the added step of combining multiple indices in the desired proportions. To do this, determine the relative proportions of the indices to be included in the composite and calculate a weighted average of the indices (not to be confused with a "weighted index" as described in the next section, which is a single index that is weighted across the outlay period).

After you have created your custom raw index, determine whether you require a weighted index and, if so, identify an outlay profile that reflects the expected phasing of expenditures over time. The next section includes instructions for applying an outlay profile to a raw index to create a weighted index.

E. Making weighted indices

As described in Chapter 6, weighted indices apply outlay profiles to raw indices[34] to account for the fact that obligations may not be fully expended in the year in which they are labeled in a budget document or cost estimate. Outlay profiles are based on historical expenditure rates for obligations in each major DoD appropriation, and are published annually by the Office of the Under Secretary of Defense (Comptroller) in the President's Budget Green Book, Chapter 5.

The formula to produce a weighted index appears complex at first glance because it combines several mathematical steps into a single multiplier for ease of use. This section will first explain the denominator on its own, followed by the overall formula. The formula is best understood through examples, but the overall formula is as follows:

$$W_t = \frac{1}{\sum_{i=t}^{n}\left(\frac{P_{i-t}}{R_i}\right)} = \frac{1}{\frac{P_0}{R_t} + \frac{P_1}{R_{t+1}} + \frac{P_2}{R_{t+2}} + \cdots + \frac{P_{n-t}}{R_n}}$$

Definitions: W_t = weighted index value for year t
P_{i-t} = outlay rate for year $i-t$ of outlay profile
R_i = raw index value for year i
t = year requiring weighted index value
$n - t + 1$ = number of years in outlay profile

Note: The number of terms in the denominator will be equal to the number of years in the outlay profile.

1. Understanding the denominator of the weighted index formula

The purpose of the denominator in the weighted index formula is to measure the aggregate change in the value of funds over the course of the outlay profile. In other words, the denominator accounts for the fact that each portion of an obligation that is expended in subsequent years will have different buying power than the portion expended in the year of obligation. Each term in the denominator divides those portions (which represent different buying power) by the raw index for that year, thereby restating the outlay profile in terms of equivalent buying power (in the base year of the index). The summation of these terms measures the aggregate loss (in the case of positive escalation) or gain (in the case of negative escalation) of buying power, phased appropriately for the

[34] This handbook recommends creating weighted indices for only inflation or escalation. Although it is possible to find or create raw indices that measure only real price change, and to further apply outlay profiles to create weighted versions, the use of raw and weighted real price change indices is inadvisable. Even when used correctly, conversions using weighted real price change indices (such as to convert between CP$ and CY$ obs directly) produce slightly different results than the conceptually equivalent conversions that go through a TY$ obs intermediate (see Chapter 6 section A) due to order-of-operations issues.

expected timing of costs. For example, assume a raw index (Base Year 0) and a three-year outlay profile with the following values:

Raw index:	**Outlay profile:**
$R_0 = 1.0000$	$P_0 = 20\% = 0.20$
$R_1 = 1.0200$	$P_1 = 50\% = 0.50$
$R_2 = 1.0404$	$P_2 = 30\% = 0.30$
$R_3 = 1.0612$	
$R_4 = 1.0824$	

The denominator to calculate the weighted index value for the base year (Year 0) is provided below, with each term labeled with a letter for further description:

$$Denominator\ of\ W_0 = \underbrace{\frac{0.20}{1.0000}}_{A} + \underbrace{\frac{0.50}{1.0200}}_{B} + \underbrace{\frac{0.30}{1.0404}}_{C} = \underbrace{0.2000}_{D} + \underbrace{0.4902}_{E} + \underbrace{0.2884}_{F} = \underbrace{0.9786}_{G}$$

Item: A B C D E F G

Item	Narrative description
A	20% of the obligated amount will be spent in a year with buying power equivalent to that of the obligation year.
B	50% of the obligated amount will be spent in a year requiring 1.0200 times the buying power of the obligation year.
C	30% of the obligated amount will be spent in a year requiring 1.0404 times the buying power of the obligation year.
D	20% of the obligated amount is still worth 20.00% by the time it is expended from the Treasury.
E	50% of the obligated amount is worth only 49.02% by the time it is expended from the Treasury.
F	30% of the obligated amount is worth only 28.84% by the time it is expended from the Treasury.
G	In aggregate, the obligated amount is worth only 97.86% of its value by the time it is expended from the Treasury.

In this example, each dollar obligated would only purchase 97.86 cents' worth of goods and services due to the decrease in the value of the obligated funds.

2. Understanding the overall structure of the weighted index formula

The weighted index formula takes the inverse of the calculated change in buying power (shown in the previous section) to create a multiplier that compensates for it. In other words, the multiplier will adjust the value to be obligated to ensure that it will include sufficient funds to pay for a decrease in buying power (for positive escalation) and exclude unnecessary funds if an increase in buying power is anticipated (for negative escalation). To continue the example from the previous section:

$$W_0 = \underbrace{\frac{1}{0.9786}}_{\textbf{H}} = \underbrace{\frac{1.0219}{1}}_{\textbf{J}}$$

Item: **H** **J**

Item	Narrative description
H	Each dollar obligated will purchase 97.86 cents' worth of goods/services over the defined outlay period. A program using this appropriation may only be able to purchase 97.86% of its desired goods/services if it does not account for the expected decrease in buying power over the outlay period.
J	To purchase one dollars' worth of goods/services over the defined outlay period, $1.0219 must be obligated. A program using this appropriation should obligate 1.0219 times what the cost would have been if expended entirely in the year of obligation.

Follow the above instructions to calculate weighted index values for each year required. For example, the weighted index values for the next two years in the above example would be:

$$W_1 = \frac{1}{\frac{0.20}{1.0200} + \frac{0.50}{1.0404} + \frac{0.30}{1.0612}} = \frac{1}{0.9594} = 1.0423$$

$$W_2 = \frac{1}{\frac{0.20}{1.0404} + \frac{0.50}{1.0612} + \frac{0.30}{1.0824}} = \frac{1}{0.9406} = 1.0632$$

F. Changing the base year of an index

The base year of an index is the year relative to which price change is measured for all other years. For raw indices, the index value will be 1 for the base year. For weighted indices with an outlay profile of more than one year, the index value for the base year will be greater than or less than 1 to account for the price change during the outlay period.

The year to which an index is baselined does not affect escalation calculations directly because the ratio of $Index_{out}$ to $Index_{in}$ in the equation in section A will be the same regardless of the index base year.[35] Because changing the base year of an index will not change your results, you may wish to do so to match the base year of your estimate or to match the base year of another index for comparison.

[35] Note that the example provided in this section does not perfectly demonstrate this relationship because the index values have been rounded for display purposes. In practice, you should maintain as many decimal places as possible in all uses of indices. For weighted indices, this calculation will capture annual changes and year-to-year changes in the outlay profile itself.

To change the base year of any raw index, simply divide every value in the index by the index value for the desired base year as shown in Figure 7-3. The example below shows an index with an original base year of 2018 and the calculations required to change the base year to 2021. Note that the year-over-year rate of change is the same regardless of the index base year. You cannot perform this procedure on weighted indices—you would have to adjust the raw index first and then reapply the outlay profile (which may vary from year to year) to create a new weighted index.

Figure 7-3. Re-baselining a raw index.

Index Year	Original Index (Base Year 2018)	Change from Prev. Year	Calculation to Change Base Year to 2021	New Index (Base Year 2021)	Change from Prev. Year
FY16	0.9382	N/A	0.9382/1.0980=	0.8544	N/A
FY17	0.9804	4.5%	0.9804/1.0980=	0.8929	4.5%
FY18	1.0000	2.0%	1.0000/1.0980=	0.9107	2.0%
FY19	1.0300	3.0%	1.0300/1.0980=	0.9380	3.0%
FY20	1.0609	3.0%	1.0609/1.0980=	0.9662	3.0%
FY21	1.0980	3.5%	1.0980/1.0980=	1.0000	3.5%
FY22	1.1365	3.5%	1.1365/1.0980=	1.0350	3.5%
FY23	1.1819	4.0%	1.1819/1.0980=	1.0764	4.0%
FY24	1.2292	4.0%	1.2292/1.0980=	1.1195	4.0%
FY25	1.2784	4.0%	1.2784/1.0980=	1.1642	4.0%

8. How to Minimize Errors and Bias

The instructions provided in the previous chapter involved many inputs, any of which could contain errors or biases that would affect the results of escalation calculations. Even small variances in inflation and escalation inputs can influence total costs, particularly for estimates over long time periods or that involve goods and services with high rates of price change (either positive or negative). Underestimating escalation can lead to a significant loss of buying power as a program proceeds through its life cycle, and overestimating escalation could overcommit resources that could fund other priorities instead.

This chapter will highlight the difference between making an avoidable mistake in calculations and making an assumption that will bias your results. You may not always have all the information you require to complete the instructions in the previous chapter, and will have to fill in the gaps with the best information you have. You should seek to understand and document whether your assumptions are more likely to over- or underestimate costs, and provide that information to decision makers when it could affect their decisions.

Note that the original input value (as characterized in Chapter 4) can be a source of error or bias in and of itself; refer to the Joint Agency Cost Schedule Risk and Uncertainty Handbook (JA CSRUH)[36] for a complete discussion of risk and uncertainty in cost estimating.

A. Avoiding avoidable errors

The "avoidable" errors listed here should be fairly easy to catch in reviewing your cost model, or when presenting detailed results to a peer reviewer or your supervisor. They may occur due to improper cell references in a spreadsheet, or due to the misapplication of definitions and instructions provided in this handbook. Some of the simplest, most easily avoidable errors are as follows:

- Multiplying by an index when you should have divided, or vice versa
- Capturing inflation instead of escalation, or vice versa; may result from:
    - Incorrect interpretation of an input value (e.g., treating a budgeted value, which is actually TY$ obs, as though it is CY$ obs)
    - Improper selection of desired output type (e.g., producing a CY$ obs value for use in a budget exhibit meant to represent TY$ obs)

[36] https://www.ncca.navy.mil/tools/csruh/index.cfm

    - Misunderstanding the scope of price change included in the selected index (e.g., using a MILPAY index to convert a TY$ to a desired CY$ output would actually produce a CP$)
- Using an inappropriate formula to represent the expected escalation trend (e.g., compound instead of linear growth, or vice versa)
- Mathematical errors in creating custom indices
- Failure to complete a sanity-check on results; for example:
    - Using an index with negative escalation in perpetuity, in such a way that total costs become negative (i.e., the item not only becomes free, but DoD appears to be paid for purchasing it such as in Figure 6-3)
    - Showing relationships between TY$ and CY$ that do not make sense given that the US economy generally does not experience deflation[37]
    - Using an index that shows an escalation rate substantially different from that observed in historical data, or used in estimates for similar goods and services; note that you may have legitimate reasons to use a substantially different escalation rate (as history is not always a good predictor of the future), but you should ensure that any such divergence is intentional and well-documented as opposed to a typographical error (e.g., 20% instead of 0.20%)

Unlike the errors listed above, which should always be avoidable, some types of errors may be avoidable in some circumstances and unavoidable in others. The following list provides some examples of such errors and describes the circumstances under which they are *avoidable*, and the next section will go into more detail about how they could be sources of *unavoidable* bias.

- Using incorrect $Year_{in}$ or $Year_{out}$ values, as with incorrect cell references in a spreadsheet; this error would change the length of time over which inflation or escalation is measured. Note: This error may be unavoidable when you must calculate $Year_{in}$ from a range for a multi-year input, as described in Chapter 7. This error may also be unavoidable if you are using costs that were incurred outside the recorded period of a contract, for example if a

[37] When normalizing a TY$ value to CY$ for a given year, TY$ > CY$ for all years after the base year ($Index_{out}$ / $Index_{in}$ > 1), and TY$ < CY$ for all years before the base year ($Index_{Out}$ / $Index_{in}$ < 1). This statement would be false only in the event of US-economy-wide deflation—the escalation rate of any specific commodity does not affect this relationship between TY$ and CY$ in any way. See Appendix C for graphics demonstrating this relationship.

contractor bulk-buys material for use in multiple contracts. See the next section on unavoidable bias in assumptions for more detail.

- Using an escalation index that represents goods and services that are not relevant to your estimate (e.g., using an aircraft procurement index to represent the escalation of military pay rates). If the index represents a substantially different rate of escalation than the goods and services you are actually estimating, you could over- or underestimate costs. Note: This error may be unavoidable if you are unable to find an index that appropriately represents the goods and services in your estimate. In this case, follow your agency's best practices, use the best index available, and try to analyze whether your program of interest is likely to experience escalation at a greater or lesser rate than that captured in the index you selected. See the next section on unavoidable bias in assumptions for more detail.
- Mixing dissimilar inputs (e.g., TY$ and CY$, or CY$ for different base years) for calculations or comparisons. You should always make sure to normalize data consistently so that you are calculating or comparing values that are "apples to apples." Failure to do so would be comparable to adding values with different units, such as pounds and kilograms, because different input dollar types are effectively different units of measure. Note: This error may be unavoidable if you must use inputs that are not labeled, thereby forcing you to make assumptions about the dollar type, or if you must use inputs that have been normalized with an unknown index. See the next section on unavoidable bias in assumptions for more detail.

B. Understanding unavoidable bias

Cost estimators must frequently make assumptions to complete estimates when incomplete information is available. Any assumption can introduce bias into your estimate, depending on whether the assumed input is higher or lower than the true value. Following is a sample list of assumptions related to inflation and escalation, and the potential impact if they turn out to be incorrect.

- **Assumption:** "I had to use a multi-year input, so I calculated a $Year_{in}$ value based on the midpoint of the range. I know some costs were incurred in other years, but I don't know the time phasing."
  Impact: The delta between $Year_{in}$ and $Year_{out}$ determines how many years' worth of inflation or escalation you capture in the conversion. Any difference between your assumed $Year_{in}$ and the true value would affect the amount of price change that is accounted for in any conversions.

- **Assumption:** "I had to use a multi-year input, so I allocated the costs to individual years based on supplemental data that may not represent the actual timing of costs incurred."
  Impact: Any conversions you make on costs that you allocated to an incorrect year will result in the application of either too much or too little price change, as described in the previous example.
- **Assumption:** "I chose an escalation index that I think is relevant to my estimate, but I don't know for sure."
  Impact: The annual rate of change in the index you selected may be higher or lower than the rate that actually was or will be experienced. You may also double-count some real price change if the index represents cost drivers that you have already estimated discretely in your estimate, or the index may omit sources of real price change that are important to the goods or services in your estimate. The magnitude of this impact will depend on the delta between assumed and actual rate of price change, as well as the time period over which price change occurs.
- **Assumption:** "I need to compare my estimate to a cost metric published in CY$, but I don't know what inflation index produced the CY$ value in the metric. I will just use the most recent inflation index because that's the best data I have right now."
  Impact: Comparing values that were normalized using different indices will conflate differences between the indices with differences between other aspects of the values. If the goal of comparing normalized values is to remove the effect of inflation, using inflation indices from different publication years could result in index-driven deltas in the normalization process.

There are also certain sources of unavoidable bias in inflation and escalation that are inherent to all cost estimates. You may not need to document these biases for your estimate, but you should understand and consider these issues so you can communicate the resulting uncertainty to decision makers.

- Cost estimators often rely on historical data as the basis of future forecasts because it is readily accessible, accepting the fact that history may not be a perfect predictor of the future. Many professional market forecasts use economic indicators—rather than pure history—to project future economic conditions, but these indicators may be neither intuitive nor easy for a cost estimator with limited resources to identify. In the absence of professional forecast recommendations such as those based on futures markets, a best practice is to examine historical price change trends and use subjective information to assess whether the same trends are likely to continue, as opposed to omitting real price change from estimates just because it is difficult to predict.

- Economic trends are not permanent, and the indices available to us may describe trends that will not last for the entire duration of weapon systems' long production timelines or life cycles. There is no way to predict how prices in any market will change over multiple decades—we must account for escalation over the full estimate period, knowing that the index values we apply for later years could be drastically different from the price change that will actually occur. This uncertainty is less significant for shorter estimate durations, but you should review the indices in your estimates regularly to ensure they remain aligned with economic forecasts, and update them when warranted.

C. Reaching valid conclusions

Failure to avoid avoidable errors or understand unavoidable biases can lead to invalid conclusions. This section will explain the possible pitfalls of presenting cost estimates to decision makers at an inappropriate level of normalization.

In general, cost values not only convey information about a specific program or cost element, but also help facilitate the comparison of disparate costs. While CP$ is a useful level of normalization for calculations and for visualizing programmatic trends, it can provide a distorted view of differing programs or cost elements that are normalized with different escalation indices. In contrast, CY$ obs provide a consistent normalization process because costs are normalized for inflation only, which is common to all programs and cost elements. Some analyses should also be presented in TY$ obs so decision makers can view the full estimate. The following sections discuss some common types of cost comparisons: affordability analyses, comparing current and baseline costs, and comparing alternative purchases.

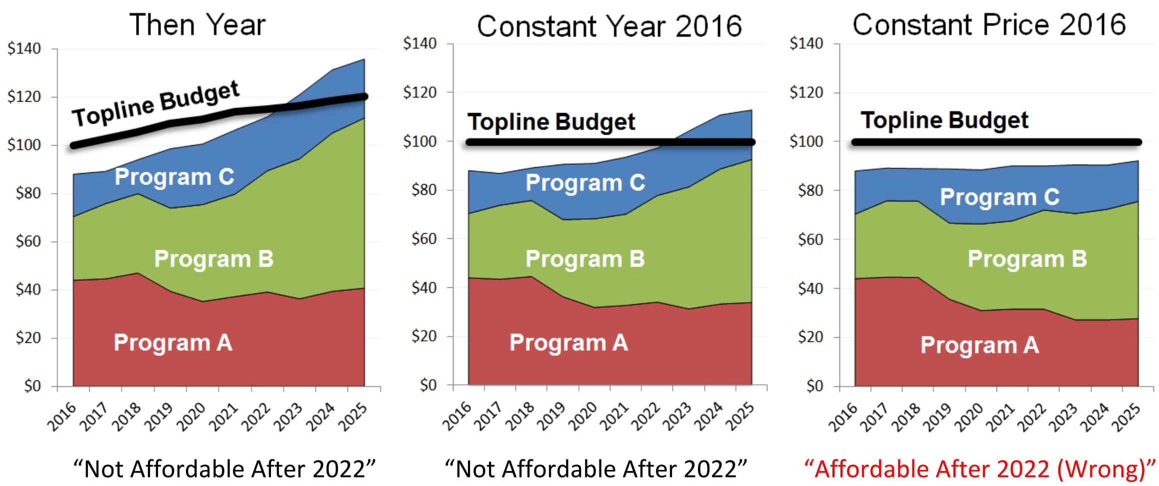
1. Affordability analysis

A reliable affordability analysis is critical to understanding whether program funding requirements fit under a future budget. An aggregate portfolio of cost estimates, combined with all other fiscal demands, must not exceed a reasonably projected topline budget. A reasonable projection of topline growth is inflation as measured by the GDPPI.

Suppose DoD is executing two programs, A and B, and wants to assess the affordability of a new program, C. The programs use a unique mix of market resources, the prices of which are expected to grow faster than the rate of overall inflation. Assume program cost estimates reflect realistic escalation assumptions, and that Program B demands more resources over time while Programs A and C demand fewer.

In the “Then Year” chart (TY$ obs) on the left in Figure 8-1 below, the program funding requirements, which grow at rates of escalation specific to each program, surpass the budget projection, which grows at the rate of inflation, in the year 2022. The set of programs is no longer affordable, and the DoD will have to make tradeoffs to stay within the topline budget—an important observation to convey to decision makers who will be responsible for directing those tradeoffs. The same conclusion is evident in the “Constant Year 2016” chart (CY$ obs), in which each program’s then-year costs and the topline budget are deflated using a common inflation index.

Figure 8-1. Comparing the budget to CP$ portfolio costs can lead to misleading affordability conclusions.



However, suppose that a cost analyst, instead of displaying this analysis in TY$ obs or CY$ obs, puts each element of the affordability analysis into CP$ using program-specific escalation indices. There is no comparable escalation index for the entire DoD budget beyond inflation, so the topline budget in the “Constant Price 2016” chart is not displayed in the same terms as programs A, B, and C; in other words, each program is normalized for escalation, but the topline budget is only normalized for inflation. The normalized costs for the programs appear to fit within the projected topline budget, but the types of dollars displayed are not comparable, and the analysis leads to an incorrect conclusion: the set of programs appears affordable after 2022 given their projected demands, when in fact it is not.

In summary, affordability analyses assess the cost impact of adding new program and budget elements to existing ones. Where elements have different escalation rates, CP$ return distorted relationships. Costs for affordability analyses should be presented in TY$ obs, CY$ obs, or both. Costs for affordability analyses should not be presented in TY$ exp or CY$ exp because DoD budgets must account for outlay profiles.

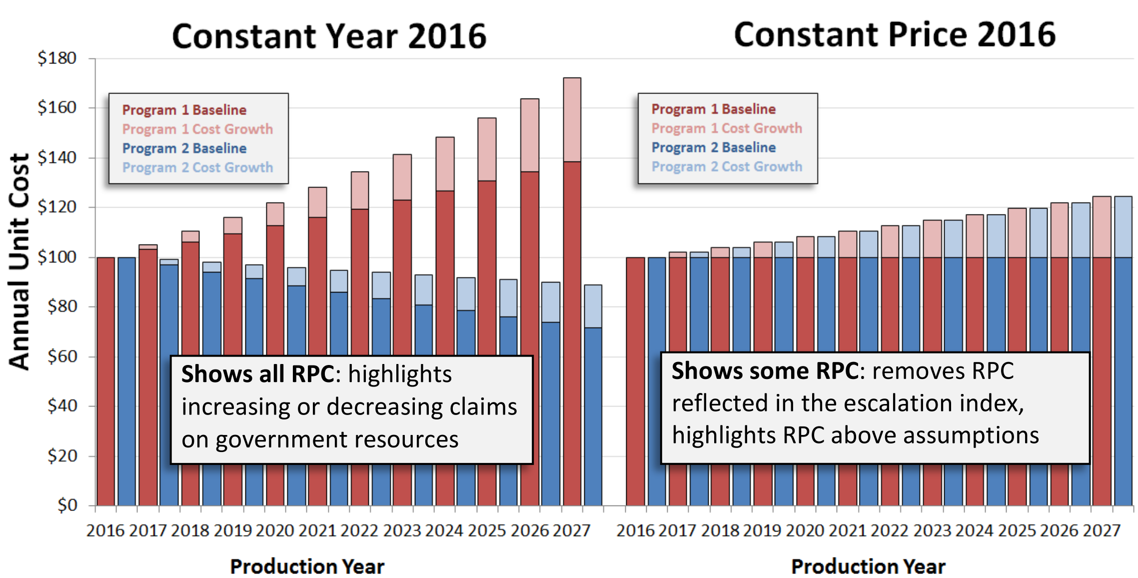
2. Comparing current and baseline costs

Program performance is often measured relative to a baseline cost objective, and growth above certain thresholds triggers additional controls and oversight. This handbook recommends that all costs related to program baselining be measured in CY$ obs, for two primary reasons.

First, CY$ obs are a shared focal point for all programs. Observers can immediately recognize that the dollars were normalized for only inflation, and draw the same interpretation. Constant prices can be created using an escalation index, but beg the question, "an escalation index of *what*?" An escalation index might measure the price change for a broad basket of goods, such as all aircraft manufacturing inputs, or a narrow basket, such as titanium. Proper interpretation of CP$ requires further investigation into the escalation index, especially when dealing with multiple values that were normalized using different escalation indices from each other.

Second, and more importantly, CY$ obs preserve the appearance of real price change, which is often important information for decision makers. Suppose two program baselines were estimated with different baseline escalation assumptions, one with a real price change of positive 3.0 percent and the other negative 3.0 percent. If both programs experienced annual escalation 2.0 percent above their corresponding baseline escalation assumptions, different views emerge in CY$ obs and CP$. A CY$ obs profile (left-hand side of Figure 8-2 below) will reflect the fact that the second program demanded fewer real resources over time, despite experiencing cost growth, while the first demanded ever-increasing resources. The same data normalized to CP$ (right-hand side of Figure 8-2 below) only shows performance to assumptions, or the fact that both programs experienced annual escalation of 2.0 percent above baseline.

Figure 8-2. Comparing program trends in CP$ can lead to misleading conclusions.



Not only will the audience's perception of program costs differ depending on the method of cost conversion, but so will the calculated average unit cost escalation. While the percent escalation in Figure 8-2 is exactly the same between the two programs in CP$, they differ in CY$ obs. Because both programs experienced an equal 2.0 percent annual escalation above baseline escalation assumptions, they realized the same percentage cost growth in CP$ (11.77%).[38] Yet when measured in CY$ obs, Program 1 shows relatively higher cost growth and Program 2 relatively lower (12.55% and 10.97%, respectively). This differential occurs because Program 1 had assumed positive real price change in the baseline, while Program 2 assumed negative real price change. The higher baseline escalation assumptions translated into higher percent cost growth in CY$ obs due to the effects of compounding growth.

As shown in the example above, displaying results in CP$ can lead to incorrect conclusions about the change in a program's cost over time. Every commodity—possibly every program—could use its own unique measure of success, choosing indices based on how they will influence decision makers' conclusions. Further, CP$ analyses are not appropriate for decision makers' consideration of opportunity costs because, in considering trade-offs across multiple portfolios, there would be no common point of comparison for the actual dollars DoD has available. Also, as shown in the example programs, the choice of an escalation index could affect whether a program appears to represent decreasing demands on the DoD's budget (which allows for more programming) versus increasing demands (which may require cuts there or elsewhere).

3. Comparing alternative purchases

Programs often have multiple courses of action available to fulfill mission requirements. Decision makers must select the most effective alternative, taking into account differences in cost, schedule, and technical requirements. Consider the following example that focuses on aspects related to cost. A system that is deployed in FY16 can undergo depot overhauls in two-year cycles with equal reliability using either a "Labor-Intensive" option or a "Material-Intensive" option. Your task is to determine the most cost effective option over a 15-year timeframe and make a recommendation to decision makers.

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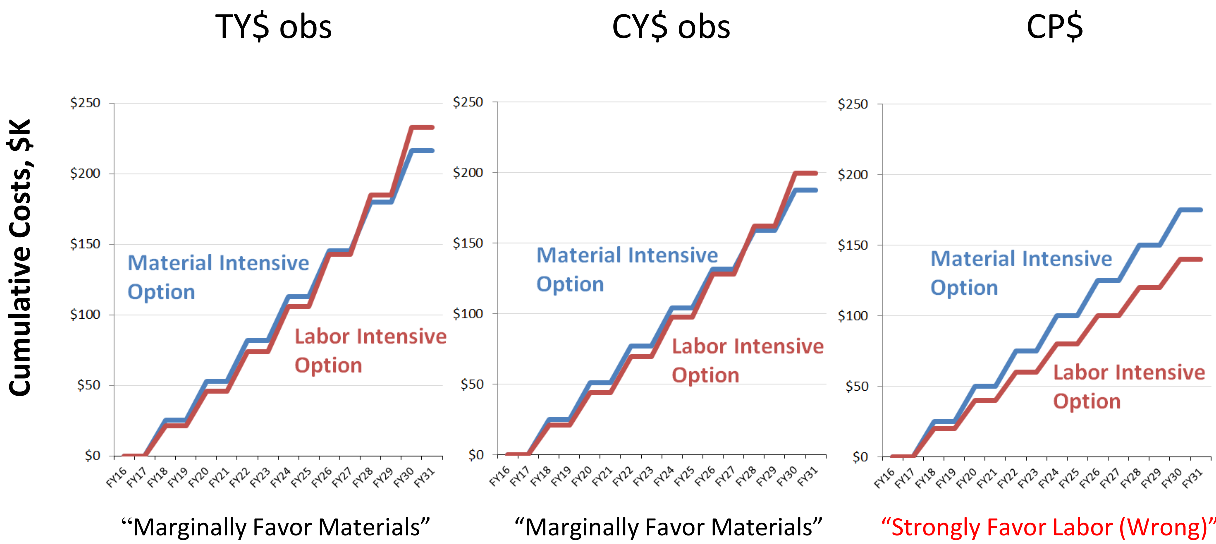
[38] Had the programs used escalation indices that depended in large part on the programs in question, there would have been 0.00% cost growth in CP$. Say that these programs represented the only purchases in their commodity group, and the escalation indices are derived from actuals from the programs in question. In this case, the final escalation indices would have incorporated the higher real price change than forecasted and normalized away any apparent cost growth. It was assumed here that the programs in question did not affect the realized escalation indices, which conformed to escalation forecasts at the time of the baseline.

Figure 8-3. Comparing alternative courses of action in CP$ can lead to misleading conclusions about the least expensive option.

	Labor-Intensive	Material-Intensive
Time between depot overhauls	2 years	2 years
Cost of depot overhaul in FY16	$20,000	$25,000
Forecasted escalation rate	7.00%	3.00%



Which alternative would you recommend to decision makers? Over 15 years, the system would undergo seven overhauls under both alternatives. By correctly applying forecasted escalation (not inflation) to the current cost of each alternative, you will return cumulative TY$ obs overhaul cost profiles (left chart of Figure 8-3 above). The 15-year sustainment costs are $217K for the Material-Intensive option and $233K for the Labor-Intensive option. In TY$, the Material-Intensive option appears marginally more cost-effective.

Then-year dollars, however, are not appropriate for comparing alternatives with different expenditure patterns over time due to the fact that different options might use different escalation rates. Remember that the purchasing power of the dollar is also changing over time; to account for the difference in expenditures due to timing differences across options, the effects of the change in the dollar's purchasing power must be removed. Deflating the stream of overhaul costs for each alternative by a common inflation index returns CY$ obs in the base year of FY16 (middle chart of Figure 8-3).

After deflating TY$ obs to CY$ obs, you calculate a Material-Intensive overhaul cost of $188K and a Labor-Intensive cost of $199K. The conclusion remains: the Material-Intensive option is marginally more cost-effective when viewed in CY$ obs. However, TY$ obs and CY$ obs can often lead to different conclusions, which may have been the case in this example if the alternatives had different overhaul cycle times.

While TY$ costs are best estimated utilizing escalation to account for all anticipated price changes, you should present alternative costs in CY$ for comparisons because doing so preserves the effects of real price change, which often differ among alternatives. The Labor-Intensive option in this example is more expensive because its projected escalation rate is considerably higher than that for the Material-Intensive option. An analysis normalizing the TY$ obs to CP$ instead (right chart of Figure 8-3) would remove all real price change, distorting the comparison. De-escalating the Material-Intensive option with a 3.0 percent annual escalation index and de-escalating the Labor-Intensive option with a 7.0 percent annual escalation index would lead to the wrong conclusion because the resulting normalized estimates are not in comparable units. This CP$ comparison incorrectly presents the Labor-Intensive option as significantly less expensive, as opposed to marginally more expensive, compared to the Material-Intensive option.

Constant-year dollars (CY$ obs) are the appropriate units for presenting the stream of costs when comparing alternatives. Decision makers need to understand which alternative is more cost-effective after removing distortions to the purchasing power of the dollar caused by different expenditure timing. Constant prices do not include potentially important information about real price change, and therefore prohibit an accurate comparison of alternatives relative to actual resources demanded.

9. Documenting and Comparing Estimates

As with any other part of a cost estimate, you should document the assumptions and methodology used when applying inflation and escalation indices. Spreadsheets containing price-adjusted data should document input data, output types, and indices thoroughly so that a subsequent analyst can reproduce the results and, if necessary, perform updates. Preferably, you should include a full copy of the indices applied in your estimate because, as shown in Chapter 5, you or a future analyst may need to "undo" your calculations later for updates or changes in assumptions. The first four sections of this chapter discuss general best practices for labeling and citing sources, and the final section provides advice for comparing estimates that were produced using different indices and assumptions.

A. Documenting assumptions

As discussed in Chapter 4, the pieces of information shown in the Documentation Checklist (reproduced here) are required for every input and output in your estimate. Chapter 7 provided recommendations for labeling these components in your spreadsheets so they will not be overly burdensome in your cost models.

DOCUMENTATION CHECKLIST

- ☐ **Value**
- ☐ **Transaction year**
- ☐ **Dollar type (TY$ obs, TY$ exp, CY$ obs, CY$ exp, CP$)**
- ☐ **Base year (if CY$ or CP$)**
- ☐ **Index applied (if CY$, CP$, or future TY$), including publication date**

You must understand these dimensions of your data in order to use them properly in an estimate; the extra effort of documenting these parameters is worthwhile, as it will facilitate reviews and future updates and ensure that you are presenting the correct results. It is especially important to document this information when you make assumptions about unknown inputs, as discussed in Chapter 4 section C, as you must understand the potential ramifications of incorrect assumptions and may want to change those assumptions later.

Another important assumption to document is the exclusion of real price change in any cost element. If you wish to assume that a commodity relevant to your estimate does not experience real price change (i.e., prices grow at the rate of inflation only), you must document and defend that decision.

B. Dollar labels on charts and tables

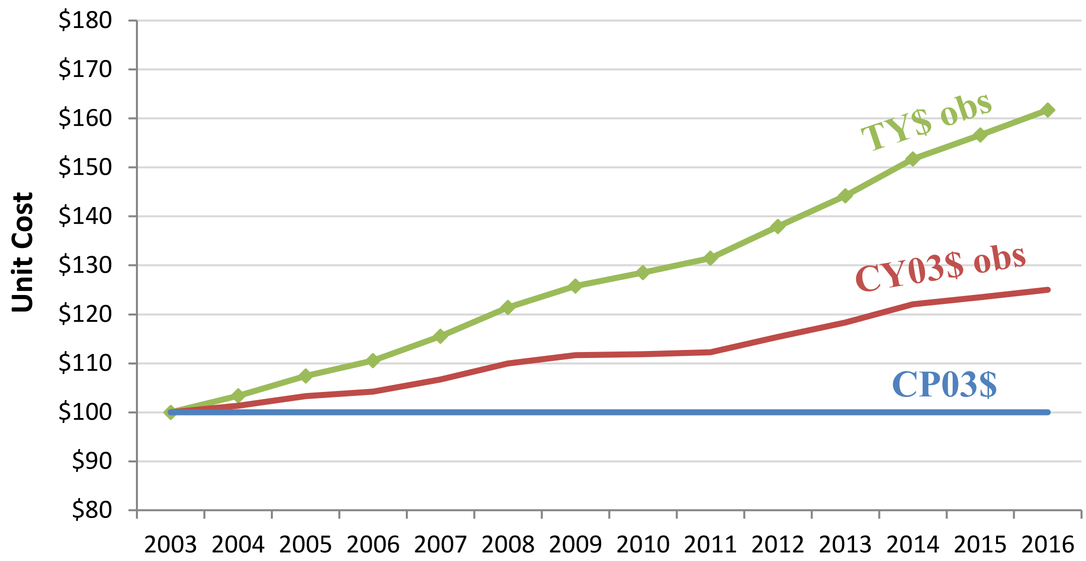
Dollar values in charts and tables should be labeled TY$ obs, TY$ exp, CY$ obs, CY$ exp, or CP$, and the base year specified for the latter three.

> Then Year. Dollars unadjusted for relative price changes, which represent the actual amount of dollars needed at a point in time to meet an obligation or expenditure. You should specify whether TY$ represent obligations or expenditures, though you may decide to make this information less prominent depending on the audience; for example, final cost estimate results presented in TY$ obs may be labeled as only "TY$" in a briefing for senior leaders, but it would be wise to include a reference to "TY$ obs" in the speaker's notes for those slides. If the figure makes the time-phasing of TY$ clear, no reference to a transaction year is needed. If the time-phasing is not clear, each data point should be labeled to show its transaction year.
>
> Constant Year. Dollars adjusted using the GDPPI, which represent the amount of dollars needed if no inflation had occurred relative to the stated base year. As described above for TY$, you may omit the "obs" or "exp" labels on CY$ charts for certain audiences, but may wish to include less conspicuous notes about the specific CY$ type for future reference. Constant-Year dollars should always be labeled to show both the base year and transaction year, as discussed in Chapter 2.
>
> Constant Price. Dollars adjusted with a specific price index or costs modeled without the effects of escalation, which represent the amount of dollars needed for a purchase excluding the effects of inflation and some or all of real price change. Constant prices should always be labeled to show both the base year and transaction year, as discussed in Chapter 2. It is recommended that a proper index citation follows in a footnote, bibliography, speaker notes, or back-up slides. Recall from Chapters 5 and 8 that CP$ are not generally recommended for use in external reports.

You will often encounter charts and tables with ambiguous dollar-type labels, such as fiscal year dollars, base year dollars, constant dollars, or constant budget dollars. These terms often have a base year that can indicate normalization, such as "BY17," but it may not be clear whether an inflation or escalation index was used. "FY" dollars can, depending on the case, refer to dollars that are normalized as well as those that are not. If and when it is necessary to use an ambiguous label, annotate appropriately using the standard terminology, as presented in this handbook, to convey the precise meaning.

As discussed in Chapters 5 and 8, costs should usually be presented in only TY$ obs or CY$ obs. For proper interpretation, these options only require clear labeling. When you display CP$ in a chart or table, you should include citations and interpretations for the escalation indices used, whether in a footnote, a bibliography, speaker notes, or back-up slides. In general, CP$ are used in the analytical process and should not be presented unless you also provide proper context. Figure 9-1 below gives an example of suggested chart labeling.

Figure 9-1. Example: Labeling TY$ obs, CY$ obs, and CP$ in charts.



C. Documenting use of a published index

Published price indices are those which come from an authoritative source, whether government, industry, or academic. Some of the relevant price indices available to cost analysts are discussed in Appendix B. The best practice for documentation is to list the price indices used. The general form for citing an index is as follows:

Author/Agency, *Data Series Name* (Unique Index Description/Identifier), Publication Date, "retrieved from" Publisher Name, Web Address, "last actual" time period.

The information available for citing data series is not standard, and unique identification codes are not always provided. Even where they are, a description of the index is recommended to be provided in the title as well. The four primary attributes for describing a specific index within a data series are industry, item, geography, and

Published Index Citation Examples:

U.S. Bureau of Labor Statistics (BLS). *Employment Cost Index* (Total Compensation for U.S. Aircraft Manufacturing, ECIPCAIRNS.Q.FOS), May 2015, retrieved from IHS Global Insights, https://www.ihs.com/products/us-economic-forecasts-and-analysis.html, last actual Dec. 2014.

Naval Center for Cost Analysis (NCCA). *FY17 Joint Inflation Calculator* (MILPAY), Feb. 2016, retrieved from Cost Assessment Data Enterprise (CADE), https://www.cade.osd.mil, last actual 2015.

qualifiers. In the first example shown below, the specific price index used from the ECI had the unique ID of ECIPCAIRNS.Q.FOS. We can describe this index with our four attributes: the industry is aircraft; the item is manufacturing labor; the geography is the entire U.S.; and the qualifier is that it represents total compensation (as opposed to wages or benefits alone). Other qualifiers can include whether the index was seasonally adjusted or not, or whether the index represents the mean of the observations, or some percentile, like the 75th.

The "last actual" time period conveys the last observed date recorded in the price index. Some price indices are forecasts of the future where there is no "last actual" date. In such cases, use "forecast start" and the time period where the price index forecast starts. In other cases, the professional forecast does not extend out long enough, requiring you to perform your own forecast (see Chapter 6 section D and Chapter 7 section D for instructions). Such instances of extending professional forecasts should be documented as a separate entry that follows the Custom Index style. Where composites are used, simply list the indices used as if they had been applied independently in the form shown above, and make sure to document the relative proportions applied.

D. Documenting use of a custom index

This handbook provides numerous published escalation resources for the analyst to apply. They cover most commercial end items and supply-side inputs, such as labor and material. Yet there are often useful data not incorporated into published indices that are available to the analyst. Research into creating custom indices is encouraged where sufficient time and manpower can be applied. See Chapter 6 section D and Chapter 7 section D for instructions.

Custom indices come in several forms, but are generally either historical estimates or future extrapolations based on datasets that are either published or unpublished. For example, a time series of labor rates received directly from the contractor would be considered unpublished data, from which a custom index could be derived.

The general form for custom indices based on published sources is as follows:

"Custom Index based on published data from" Author/Agency, *Data Series Name* (Unique Data Description/Identifier), Publication Date, "retrieved from" Publisher Name, Web Address, "last actual" time period.

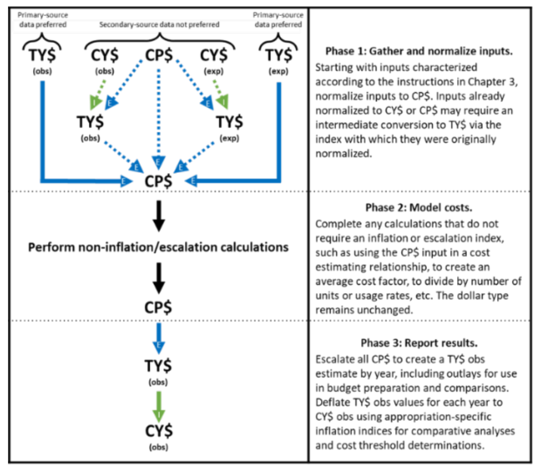
The general form for custom indices based on unpublished sources is as follows:

"Custom Index based on unpublished data from" Source/Provider, *Unique Data Description/Identifier*, "retrieved from" Source Contact/Location, "last actual" time period.

E. Estimate review and reconciliation

With the increased use of escalation indices from a variety of sources, it may become more difficult to review and reconcile estimates. As shown in Figure 5-2 (reproduced in miniature here), a typical estimate will include several layers of conversions for each input, and differences in assumptions such as the dollar type or index applied could drive deltas that compound and permeate the cost model. Consider questions like the following to identify sources of deltas:

1. Initial normalization (any dollar type to CP$): Do you agree with the diagnosis of input dollar type, base year (if applicable), transaction year, value, and choice of any indices applied?



2. Non-inflation/escalation calculations: Do you agree with the calculations applied (e.g., CER methodologies, rates of learning)? This step will likely be the focus of estimate reconciliations.

3. Forecasting assumptions (CP$ to TY$ obs): Do you agree with the forecasted escalation rate and outlay profile applied to reach the TY$ obs estimate for each cost element?

4. Inflation index selection (TY$ obs to CY$ obs): Do you agree with the inflation index selected, and does the outlay profile match the one reflected in the TY$ obs estimate?

Some assumptions may be more controversial than others; for example, the last step in the list above should not generate much discussion, as only one type of index (inflation) applies. For the other steps in which analyst judgment plays a greater role, note that there are few "right" or "wrong" assumptions in selecting escalation indices—the key is to document your decisions so that you can explain them, and change them later if desired. Remember to always consult your agency best practices to promote consistency and facilitate the review process with your leadership.

When comparing your results with those of another analyst, comparisons in CP$ may help you discover differences in programmatic assumptions and non-inflation/escalation calculations—provided you used the same escalation indices to reach CP$. Comparisons in TY$ obs will help you understand differences in forecasting assumptions, though they may compound with other deltas elsewhere in the estimate methodology.

10. Conclusion

This handbook provided the best practices for inflation and escalation in cost estimates. Hopefully it has helped you understand the terminology changes of the past few years, and you are well-prepared to apply these concepts in your estimates. You can always reach out to OSD CAPE with any questions.

There are several topics related to inflation and escalation that still require research, and will be reflected in later guidance. The following topics constitute the “parking lot” of items that arose during the writing of this handbook:

1. Alternative methods of calculating indices, comparing methods such as year-over-year changes (e.g., January 2019 to January 2020) vs. monthly rolling average changes, and calendar year vs. government fiscal year indices.
2. Converting monthly indices to annual indices, and vice versa.
3. List of common data sources and how to treat inputs from them.
4. Relationship of inflation and escalation indices to productivity indices.
5. Hierarchy of trusted indices: what sources are “best” for which applications?
6. Quantifying and modeling risk and uncertainty in escalation inputs.
7. More examples, including how to estimate the escalation impact of a program schedule slip.
8. Durability of economic trends, modeled via hybrid approaches to index construction (e.g., incorporating real price change in the near future and converging to inflation after some period of time) to account for expected market corrections.
9. Relationship of inflation and escalation to discounting and net present value.

Appendix A. Glossary

Definitions in this glossary may exclude advanced concepts found in other training materials, or may be tailored for relevance to inflation and escalation. Readers are encouraged to seek further information on these terms, both within this handbook and from other sources.

Average cost factor. For this handbook: A value produced by dividing multiple years' worth of costs by any denominator (e.g., five years of costs divided by five years of flying hours to produce average cost per flying hour). The costs for the numerator in these factors should be normalized to CP$ prior to calculating the factor, using a single escalation index and the same base year to normalize all cost inputs.

Base Year (BY). The year against which costs are measured for comparison, as in CY$ and CP$, or the year of an index relative to which prices are measured, as in the base year of a general inflation index.

Base Year Dollars (BY$). This is an ambiguous term no longer recommended for use. Costs previously labeled "base year dollars" may refer to either CY$ or CP$ under the current definitions, depending on the type of index used to produce them.

Cost Estimating Relationship (CER). An equation that relates costs to one or more independent variables. These equations should be produced using input data that has been normalized to CP$, using a single escalation index and the same base year to normalize all cost inputs.

Cost Improvement Curve (CIC). An equation that measures the relationship between costs and time-correlated learning and/or rate effects. These equations should be produced using input data that has been normalized to CP$, using a single escalation index and the same base year to normalize all cost inputs.

Commodity. For this handbook: A good or service that is generally interchangeable with other goods and services of the same type. Cost estimates include multiple commodities, which may be organized by elements in a Work Breakdown Structure or Cost Estimating Structure. Commodities may be characterized at many levels of detail, from the full end item to subsystems to particular labor categories and material types.

Composite index. An index that represents multiple commodities, each of which is characterized by a unique index, combined in proportions that represent a particular market basket. Composite indices may be either raw or weighted; if any portion of the composite index includes an outlay profile, the whole index should be treated as a weighted index. Some composite indices include both inflation-only indices and indices that include real price change; if any portion of the composite index includes real price change, the whole index should be treated as an escalation index, with an inherent assumption of zero real price change on cost elements described by the inflation-only portions of the index.

CONSTANT PRICE (CP$). A cost that has been normalized relative to a selected base year via an escalation index, or that is used as a "flat-line" modeling technique for subsequent application of escalation. Constant prices do not include the effect of escalation (i.e., neither inflation nor real price change) relative to the base year, nor do they include the effect of outlay profiles. Costs should generally be normalized to CP$ prior to performing calculations, but costs should not generally be presented to decision makers in CP$.

CONSTANT-YEAR DOLLARS (CY$). A cost that has been normalized relative to a selected base year via an inflation index. Constant-year dollars exclude the effect of inflation relative to the base year, and include real price change. Also known as "real dollars" outside the DoD community. There are two types of CY$, as determined by the TY$ type from which they were created; removal of inflation from TY$ obs creates CY$ obs, and removal of inflation from TY$ exp creates CY$ exp. There is no outlay profile present in CY$ exp, but CY$ obs include the effect of the outlay profile on the real price change included. Obligations-oriented CY$ obs, in addition to TY$ obs, are often used in reports for customers external to the cost estimating community.

ESCALATION. The total change in price of a good or service over time, including both economy-wide inflation and commodity-specific real price change. Depending on the circumstances, escalation may be positive, negative, or zero, and may or may not be equal to inflation.

EXPENDITURES. A type of transaction that reflects an actual disbursement from the US Treasury at a particular point in time. Unlike obligations, expenditures do not include an outlay profile to account for a time delay between recording the transaction and the disbursement of funds from the Treasury.

FISCAL YEAR. For the federal government, the period of time from October 1 to September 30.

GROSS DOMESTIC PRODUCT PRICE INDEX (GDPPI). An index that measures the change in the US Gross Domestic Product over time, and that should be used for federal budgeting purposes. The index is available in multiple DoD-published documents, and originally published by the Office of Management and Budget in Historical Table 10.1, available at: https://www.whitehouse.gov/omb/historical-tables/

Index (Indices). A table of values measuring the change in prices of a particular commodity, or "market basket" combination of commodities, relative to a stated base year. Indices may measure inflation or escalation, and may or may not be weighted via an outlay profile. Indices measuring real price change alone are not recommended for use in cost analysis.

Inflation. The aggregate change in value of the US dollar over time, as measured by the GDPPI for federal budgeting purposes.

Input. Any cost value, from a primary or secondary source, obtained for use in the preparation of a cost estimate. When inputs are converted to outputs via intermediate calculations for a cost estimate, intermediate outputs may then become the inputs of further calculations before a final cost output is presented. Inputs may represent a variety of cost types, and must be characterized correctly prior to use in calculations.

Learning curve. An equation that measures the relationship between labor hours and time-correlated learning and/or rate effects. Because these equations are produced with inputs other than costs, there are no inflation- or escalation-related issues associated with their production. A learning curve would yield the same results as a Cost Improvement Curve produced with data normalized to CP$ if and only if the index used perfectly describes (and removes) all escalation from the historical data.

Multi-year or cross-year inputs. Cost inputs that are not attributable to individual years without the use of a supplemental data source, for example total costs of a contract with a three-year period of performance. These inputs must be attributed to a single year prior to using them for inflation or escalation calculations, either by treating them as belonging to a single year (e.g., the midpoint) or using an allocation method (i.e., phasing profile) to assign portions of the total costs to single years.

Nominal dollars. Also known as Then-Year Dollars, this term is used more frequently outside the DoD environment.

Normalization. For this handbook: The removal of inflation or escalation from a cost value to restate the value relative to a base year (i.e., the creation of CY$ or CP$, respectively). These calculations adjust costs to remove time-correlated distortions prior to performing other cost estimating calculations, or restate values in equivalent terms for direct comparisons.

Obligations. A type of transaction that represents an amount of funds expected to be expended either during or after the year of obligation. Obligations have been adjusted to include an outlay profile that accounts for the anticipated change in buying power during the time that elapses between obligation and expenditure.

Outlay profile. A set of percentages (which sum to 100%) that shows the timing pattern in which obligated funds are typically expended, or expected to be expended, for particular appropriations. For Department of Defense appropriations, the longest outlay profiles extend from the year of obligation through nine subsequent years, while the shortest represent "one-year money" that is fully expended in the year of obligation. The application of outlay profiles to raw indices produces weighted indices.

Output. The result of any calculation in a cost estimate, which may subsequently become an input of a later calculation. The desired dollar type for a given output should be selected carefully to ensure that it is appropriate for the analysis being performed.

Phasing profile. For this handbook: An allocation method for reassigning multi-year or cross-year inputs to individual years for use in inflation or escalation calculations. For example, a potential phasing profile for a three-year contract amount may be the labor hours per year or relative value of material invoices per year, either of which may be an appropriate proxy for understanding the timing of costs by year.

Primary vs. secondary sources. For this handbook: Primary sources represent unmanipulated data, such as obligations or expenditures as they were recorded at the time of the transaction; secondary sources represent pre-normalized data, such as inflation-adjusted (CY$) or escalation-adjusted (CP$) costs from an automated database. Cost analysts should use data from primary sources whenever possible in order to avoid the uncertainty that may arise when using data that was previously normalized by an incorrect index, or by an index that is not appropriate in the context of a particular calculation.

Raw index. An index that does not include the effect of an outlay profile.

Real dollars. Also known as Constant-Year Dollars, this term is used more frequently outside the DoD environment.

Real Price Change (RPC). The rate of change in prices for a specific commodity, or market basket of different commodities, excluding economy-wide inflation. This handbook recommends breaking down real price change into the effects of quantity changes, quality changes, and pricing changes for cost estimating purposes.

Then-Year Dollars (TY$). Costs that reflect the value of money at the time of a transaction. The type of transaction defines the two types of TY$: obligations (which include outlay profiles) and expenditures (which do not include outlay profiles). Also known as "nominal dollars" outside the DoD environment.

Transaction year. The point in time at which an obligation is obligated or an expenditure is expended. Most commonly modeled as "Fiscal Year" columns in a phased cost estimate.

Weighted index. An index that includes the effect of an outlay profile.

Appendix B. Resources

A. Service-level indices

Since some of the OUSD(C) guidance is inflation and some escalation, the published Service-level indices will also contain inflation and escalation. It is important for analysts to read notes and instructions accompanying an index to ensure correct usage.

1. Air Force indices

Starting in FY16, the raw Air Force Indices separate price escalation indices from inflation indices and provide them proper labeling. There are six price escalation indices: fuel; general schedule and wage board pay; and four related to military compensation. The raw inflation index is repeated for various appropriations. Figure B-1 below shows an excerpt from the Air Force raw index tables with escalation indices (labeled “SPECIFIC PRICE INDICES”) highlighted in blue.

Figure B-1. Excerpt from Air Force raw indices.

USAF Raw Inflation Indices Based on OSD Raw Inflation Rates Base Year (FY) 2016											
	SPECIFIC PRICE INDICES						INFLATION INDEX				
	Military Compensation				General Services & Wage Board Pay (3400)	Fuel	Operations & Maint. Non-Pay, Non-POL (3400)	Research, Develop., Testing, Evaluation (3600)	Military Construct. (3300)	Aircraft, Space & Missile Procurement (3010/20/21)	Ammo & Other Procurement (3011/3080)
Fiscal Year	Pay Base (3500)	Other Expenses (3500)	Total (3500)	Retirement (3500)							
2012	0.951	0.959	0.952	1.039	0.971	1.089	0.949	0.949	0.949	0.949	0.949
2013	0.967	0.972	0.967	0.988	0.971	1.181	0.963	0.963	0.963	0.963	0.963
2014	0.978	0.981	0.978	1.009	0.978	1.146	0.977	0.977	0.977	0.977	0.977
2015	0.988	0.989	0.988	1.013	0.988	1.079	0.988	0.988	0.988	0.988	0.988
2016	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2017	1.015	1.014	1.015	1.015	1.015	0.918	1.018	1.018	1.018	1.018	1.018
2018	1.031	1.027	1.031	1.032	1.031	0.962	1.036	1.036	1.036	1.036	1.036
2019	1.048	1.041	1.047	1.048	1.048	0.995	1.057	1.057	1.057	1.057	1.057
2020	1.066	1.057	1.066	1.066	1.066	1.021	1.078	1.078	1.078	1.078	1.078

The Air Force escalation indices do not have multi-year outlay profiles associated with them; i.e., the funds for pay and fuel are generally expended in the year of the appropriation. Therefore, normalization of pay and fuel dollars can be performed using the raw index and no weighted variants are available. It is important to note that all of the weighted indices the Air Force publishes are inflation indices. The weighted indices differ only by the OUSD(C) outlay profiles imparted onto them. See Chapter 7 section E for further information about calculating weighted indices.

One unique aspect of the Air Force weighted indices is that some of the indices are labeled “Special” while others are labeled “Other.” The “Special” indices are intended to be used for classified programs within that appropriation. For example, an analyst wanting to normalize a classified aircraft program for inflation would select the index with the heading “Aircraft Procurement Special (3010).” Conversely, to normalize an unclassified Aircraft program for inflation, the analyst would utilize the index with the heading “Aircraft Procurement Other (3010).”

The Air Force Indices are hosted under Inflation on the TOOLS page of the Cost Assessment Data Enterprise (CADE), http://cade.osd.mil/.

2. Army/Navy Joint Inflation Calculator (JIC)

Each year, the Army and Department of the Navy publish the Joint Inflation Calculator (JIC) which provides raw and weighted indices for specific categories and base years. Like the Air Force Indices, the JIC contains both inflation and escalation indices. As of the FY16 JIC, 14 of the Navy’s 35 indices reflect some degree of real price change. Of the Army’s 26 indices, six are escalation indices. The JIC also includes eight defense-wide indices, none of which reflect escalation (i.e., all are based on the GDPPI).

In general, escalation-related indices in the JIC come in three types:

1) Pay (denoted by “Pay”) and Fuel (denoted by “Fuel” or “_F”)
2) Composite (denoted by “COMP”)
3) BLS History (denoted by “BLS HIST”)

Figure B-2 below shows an excerpt of Navy indices from the JIC with escalation indices highlighted in blue. All other indices are based on inflation only.

Figure B-2. Excerpt of Navy weighted indices from the JIC.

This sheet displays the user selected index, Weighted or Budget Year, for all appropriations
Note * indicates OSD cost element (OSD Fuel may differ significantly from FMB Fuel rates in the Budget Window)

Enter Base Year (1970-2024) → 2016 | Select → Index: Weighted Index

	APN	BRAC	BRAC ER	Civ Pay*	ENV REST	FH (Con) Purch	FH (Ops) Purch	FH Con COMP	Fuel*	Mil Pay*	Milcon COMP	Milcon DoD	Milcon Purch	Milcon Res Purch	MPMC COMP	MPMC Non-pay	MPN COMP	MPN Non-pay	NDSF	NDSF (BLS HIST)
2007	0.8921	0.8823	0.8884	0.8803	0.8884	0.9013	0.8756	0.8762	0.6724	0.8288	0.8827	0.8953	0.8922	0.8936	0.8291	0.8690	0.8284	0.8677	0.8840	0.8070
2008	0.9055	0.8986	0.9025	0.9083	0.9025	0.9150	0.8936	0.8956	0.9085	0.8552	0.8991	0.9095	0.9074	0.9073	0.8551	0.8891	0.8545	0.8881	0.9012	0.8394
2009	0.9181	0.9095	0.9090	0.9429	0.9090	0.9294	0.9060	0.9110	0.6250	0.8877	0.9154	0.9272	0.9198	0.9199	0.8866	0.9021	0.8863	0.9013	0.9136	0.8652
2010	0.9375	0.9225	0.9221	0.9661	0.9221	0.9444	0.9166	0.9234	0.7831	0.9190	0.9430	0.9472	0.9430	0.9438	0.9167	0.9111	0.9165	0.9099	0.9246	0.8908
2011	0.9567	0.9453	0.9389	0.9708	0.9389	0.9680	0.9342	0.9392	0.9727	0.9363	0.9651	0.9668	0.9651	0.9650	0.9347	0.9283	0.9346	0.9284	0.9463	0.9265
2012	0.9711	0.9605	0.9541	0.9708	0.9541	0.9833	0.9501	0.9529	1.0028	0.9508	0.9801	0.9813	0.9801	0.9801	0.9495	0.9445	0.9497	0.9455	0.9619	0.9504
2013	0.9823	0.9751	0.9683	0.9708	0.9683	0.9989	0.9656	0.9663	1.0871	0.9668	0.9954	0.9969	0.9954	0.9889	0.9651	0.9589	0.9650	0.9588	0.9767	0.9721
2014	0.9977	0.9899	0.9827	0.9781	0.9827	1.0158	0.9800	0.9798	1.0555	0.9781	1.0119	1.0135	1.0119	1.0047	0.9771	0.9732	0.9770	0.9731	0.9920	0.9920
2015	1.0147	1.0058	0.9981	0.9879	0.9981	1.0342	0.9949	0.9939	1.0787	0.9879	1.0300	1.0317	1.0300	1.0224	0.9877	0.9871	0.9877	0.9871	1.0080	1.0080
2016	1.0333	1.0237	1.0155	1.0000	1.0155	1.0540	1.0119	1.0102	1.0000	1.0000	1.0497	1.0513	1.0497	1.0417	1.0007	1.0033	1.0007	1.0032	1.0258	1.0258
2017	1.0533	1.0431	1.0345	1.0130	1.0345	1.0748	1.0307	1.0282	0.9830	1.0130	1.0703	1.0720	1.0703	1.0621	1.0148	1.0215	1.0149	1.0214	1.0453	1.0453
2018	1.0742	1.0636	1.0548	1.0277	1.0548	1.0962	1.0507	1.0475	0.9918	1.0277	1.0917	1.0934	1.0917	1.0833	1.0305	1.0411	1.0307	1.0410	1.0657	1.0657
2019	1.0957	1.0849	1.0759	1.0431	1.0759	1.1181	1.0717	1.0677	1.0008	1.0431	1.1135	1.1152	1.1135	1.1050	1.0472	1.0620	1.0474	1.0618	1.0870	1.0870
2020	1.1176	1.1066	1.0974	1.0611	1.0974	1.1405	1.0931	1.0886	1.0098	1.0611	1.1358	1.1376	1.1358	1.1271	1.0661	1.0832	1.0661	1.0830	1.1088	1.1088
2021	1.1400	1.1287	1.1194	1.0802	1.1194	1.1633	1.1150	1.1101	1.0189	1.0802	1.1585	1.1603	1.1585	1.1496	1.0858	1.1049	1.0858	1.1047	1.1310	1.1310
2022	1.1628	1.1513	1.1418	1.0997	1.1418	1.1866	1.1373	1.1320	1.0280	1.0997	1.1817	1.1835	1.1817	1.1726	1.1058	1.1270	1.1059	1.1268	1.1536	1.1536
2023	1.1860	1.1743	1.1646	1.1194	1.1646	1.2103	1.1600	1.1543	1.0373	1.1194	1.2053	1.2072	1.2053	1.1961	1.1263	1.1495	1.1263	1.1493	1.1767	1.1767
2024	1.2098	1.1978	1.1879	1.1396	1.1879	1.2345	1.1832	1.1771	1.0466	1.1396	1.2294	1.2313	1.2294	1.2200	1.1471	1.1725	1.1471	1.1723	1.2002	1.2002

The pay and fuel escalation indices are provided directly from OUSD(C) guidance, and include no outlay profile, meaning the weighted indices shown are equivalent to raw indices (hence the value of 1.0000 in the base year of 2016). The composite indices blend an inflation index with an escalation index, such as fuel and/or pay. For example, the Family Housing Construction Composite index blends “FH Con Purchases,” an index fully based on inflation, with the Civ Pay index to produce the “FH Con COMP,” index. The last type of escalation-related index found in the JIC is calculated from NAVSEA/Bureau of Labor Statistics (BLS) estimates. These are called “BLS History” (denoted with “BLS HIST” in the JIC) because NAVSEA funds the BLS effort to calculate the past escalation rates for some military purchases. The forecast rates for BLS HIST, however, are inflation and should not be used as a basis of escalation. Note that the last BLS History actual would be two years prior to the President’s Budget (PB) for which the JIC was released (e.g., in the FY17 JIC, the last BLS History actual would be in FY15).

There are two Navy indices which have NAVSEA/BLS history and inflation forecasts, the National Defense Sealift Fund “NDSF (BLS HIST)” and Shipbuilding and Conversion, Navy “SCN (BLS HIST).” These indices are provided to give the analyst the option of using an index more closely aligned with actual industry price experience rather than adjusting solely for inflation.

The JIC is designated by PB year, so that the annual release in February 2016 was designated FY17, and was to be used for the FY17 President’s Budget (PB). It is released by the Naval Center for Cost Analysis (NCCA) and hosted under Inflation on the TOOLS page of the Cost Assessment Data Enterprise (CADE), http://cade.osd.mil/. Additional documentation is available on the NCCA website, https://ncca.navy.mil/.

3. Additional government-provided sources

The DoD and other government agencies develop specialized price indices which often go unpublished in public sources. For example, NAVSEA also produces a forecast for the ship escalation index (SCN, BLS HIST), but it remains unavailable through the JIC. NAVAIR, the air systems counterpart to NAVSEA, produces its own aircraft escalation index which is not publicly available. Various other DoD and non-DoD cost departments have commissioned studies to develop price indices for military systems and resources, such as the satellite price index from the National Reconnaissance Office (NRO). Contact your leadership for insight and access to some of these escalation resources.

B. Price indices and quality

Price indices are typically calculated by comparing the price of the same item or group of items across multiple time periods. These indices answer the question, “how much more money would you need today to buy the same basket of items that you bought yesterday (last month, last year, etc.)?” A price index captures the net effect of all market forces affecting supply and demand that go into determining price.

Cost analysts should be aware of whether any particular price index they are considering using is adjusted for quality. While a price index measures the change in price of the same item over different time periods, sometimes the item itself is not exactly the same as it was in the earlier time period due to improvements in that item's quality. For example, a price index for computers could compare the price of a computer today with the price of a computer five years ago, yet a computer available for purchase today would be of much greater capability than one available for purchase five years ago. That makes it difficult to interpret the price change in computers over time. A quality-adjusted price index will remove the effect of quality changes on price. Assuming quality generally increases over time, adjusting a price index for quality will lower the rate of growth in the price index because the index removes the portion of price increases associated with quality.

Hedonic Modeling of Price Indices

One method for determining a quality-adjusted escalation index is to use a parametric, or "hedonic," model. The model simultaneously estimates quality and escalation by attempting to explain an item's TY cost using a set of independent variables.

A variable subset explains price variation due to quality differences between items. The remaining variables are binary, or dummy, variables that represent the time-period of the observed TY cost. With quality held constant, the coefficients on the dummy time variables form the escalation index. Some hedonic models use additional variables to hold constant demand effects (such as learning and rate).

The BLS occasionally uses hedonic models to estimate price indices, such as for the laptop computer PPI.

C. Producer Price Indices

A Producer Price Index (PPI) measures changes in prices received by producers for their output (net of taxes). The Bureau of Labor Statistics (BLS) measures separate PPI's for separate industries and items. This makes each PPI a "representative" price escalation index, rather than an inflation index. The BLS tracks more than 4,100 PPI's on a monthly basis: more than 3,700 for goods and more than 400 for services. There are also PPIs available at different levels of aggregation. For example, while there is an aggregate PPI for "mining," there are also separate PPIs for specific industries within mining, such as "coal mining," "iron ore mining," "gold ore mining," and so on. This level of granularity makes PPIs a good potential source for cost estimators to find an appropriate price escalation rate. Industry-level PPIs are a weighted average of all PPIs within that industry where the weights are fixed to a base period for relatively long periods of time.

The BLS adjusts PPIs for quality and product changes that impact the costs of production, so that only prices for items of comparable attributes and qualities are measured. It does not, however, adjust for small quality and product changes that do not change the costs of production. The price effects of learning and bulk buys (and other incentive and rebate programs offered by the seller) *are* reflected in a PPI. For example, if a manufacturer charges $100 per unit for 1 unit and $90 per unit for two units, the PPI would reflect the weighted average price between $90 and $100 (depending on the number of units sold to each customer).

Analysts are encouraged to gain a basic understanding of the PPI methodology. The BLS Handbook on Methods contains a detailed chapter on the PPI. The chapter may be downloaded from the BLS PPI methods website: http://bls.gov/ppi/methodology.htm. The website also contains a description of how particular indices are calculated.

D. Bureau of Economic Analysis (BEA) deflators

The Bureau of Economic Analysis (BEA), which develops the GDPPI, also publishes deflators for the procurement of five military systems: aircraft, missiles, ships, vehicles, and electronics. These "representative" escalation indices are quality-adjusted by attributing all production costs associated with a specification change to a change in quality.[39] The approach, also occasionally used by the BLS PPI, does not measure quality by functional usefulness, but by cost of producing the new specification. Therefore, if a good inherits a new specification that costs the producer an additional dollar per item and increases the price by a dollar, no price change is observed for the quality-adjusted good. Unlike the PPI, however, the BEA deflators do not use fixed weights to control for industry composition. The index is continually reweighted to reflect the industry composition current to the observation.

BEA Deflators

The BEA deflators tend to show significantly less price growth for their respective items than BLS PPI equivalents. Reasons for the differences include:

- Military vs. civilian markets
- Quality-adjusted at the component level
- Controls for learning and rate
- Weighting methodology

For military goods, the BEA considers the value of quality changes by component. For example, aircrafts are broken down into component groups such as airframe, electronics, and engine. When comparing the quality differences between components of different aircraft, the BEA only considers prices after the 100th unit of production for a new aircraft design. The intent is to remove the effects of learning, wherein workers gain efficiencies and drive down unit costs in new production starts.

E. Public labor cost data

The BLS produces three primary surveys, described in the following subsections, from which they develop figures on the cost of employment by occupation. They include

[39] Galbraith, K.D. and Ziemar, R.C. "Deflation of Defense Purchases" in *The U.S. National Income and Product Accounts: Selected Topics*. Ed. Foss, Murray, University of Chicago Press, 1982, pg. 152.

over 800 occupations from 375 metropolitan and 170 nonmetropolitan areas for about 400 industries, using the same industry classifications as the PPIs.[40] Unlike the PPIs, however, the statistics from the BLS employment surveys are not quality-adjusted. The BLS reports observed labor costs, so the cost analyst must be aware that normalizing with indices derived from these data removes more price change than if quality, or labor productivity, were controlled for.

1. National Compensation Survey

The quarterly National Compensation Survey (NCS) measures changes in the cost of labor to employers. The total compensation costs are broken down into wages and benefits, the latter including additional breakouts like paid leave, overtime, insurance, retirement, and Social Security. The occupational categories captured in the National Compensation Survey tend to be quite broad, such as "professional, specialty, and technical" or "manufacturing." Industry attributes allow for more detailed targeting, such as "aircraft manufacturing." The results from the survey are the basis for two key price series, the Employer Cost for Employee Compensation (ECEC) and the Employment Cost Index (ECI).

The ECEC data provides the cost per hour of employment by attributes described above. For example, the average hourly compensation for U.S. aircraft manufacturing in the quarter ending December 2015 is $68.64, of which $41.84 is wages, $6.13 is paid leave, $7.11 is insurance, etc. With a time series of compensation data from the ECEC, the analyst can derive a labor cost index.

The ECI are "representative" escalation indices that use the same data as the ECEC, though ECIs are not provided for component cost elements of benefits. The analyst can only get an ECI for total compensation, wages, and total benefits. The other important difference between the ECEC and the ECI is how the industry and occupation categories are weighted. "The ECI is designed to measure how compensation paid by employers would have changed over time if the industry/occupation composition of employment had not changed from a base period, while the ECEC is designed to measure the current cost for employee compensation."[41] The BLS recommends that the ECI be used for examining changes in compensation over time, while the ECEC be used to obtain the average compensation level at a point in time.[42]

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[40] Bureau of Labor Statistics (BLS), http://www.bls.gov/bls/blswage.htm. Note that the forecasts under discussion generally include some number of years of historical values and that those historical values are often retroactively revised as much as a couple years later.

[41] Lettau, M.K., Loewenstein, M.A., and Cushner, A.T. "Explaining the Differential Growth Rates of the ECI and ECEC." *Compensation and Working Conditions.* 1997.

[42] Ibid.

2. Occupational Employment Statistics Survey

Data from the Occupational Employment Statistics (OES) is published from another survey that provides more detailed occupational, industry, and geographic categories than the NCS. For example, there are dozens of types of engineers captured, including aerospace, civil, computer hardware, electrical, mechanical, nuclear, and ship. These can be further broken out by detailed industry and metropolitan areas. For example, ship engineers' mean hourly wage fell 2.6% in Virginia Beach-Norfolk-Newport News area between May 2013 and May 2014.

The OES only provides wages and total employment with no insight into the cost of benefits. It does, however, report the mean and median wages, along with various percentiles. The analyst can then get an idea of the range and distribution of wages for that occupation, industry, and geographic location.

3. Current Population Survey

The Current Population Survey (CPS) is different from the NCS and OES in that it surveys worker's earnings and not employer's labor costs. The utility of these data are that in addition to earnings by occupation type, they provide demographic information such as age, sex, race, and education. Data from the former two surveys, however, are recommended because they tend to have more detailed occupational categories and are based on labor cost to the firm.

F. Contractor Forward Pricing Rate (FPR) data

The Administrative Contracting Officer (ACO), either from Defense Contract Management Agency (DCMA) or the Supervisor of Shipbuilding, negotiates labor rates by occupational category for defense contractor business units. It also negotiates indirect rates, which include both overhead (e.g., training and employee benefits) and general and administrative (e.g., facilities, equipment, corporate costs). The fully burdened labor rate includes the cost of a worker's wages (direct labor rate) as well as indirect costs (wrap rate). The direct and indirect rates, which typically include forecasts for five or more years, are called Forward Pricing Rates (FPRs) and are negotiated with DCMA annually.

The FPRs represent the most appropriate price data available for DoD purchases relative to a contractor's value-add. Indices derived from the FPRs can be considered an "own" escalation index with respect to normalizing labor costs (see Chapter 7). While price indices from the PPI and ECI represent specific market prices, the FPRs include yet more specific information regarding the contractor business effects on escalation. It is recommended that DoD cost analysts seek time series of FPRs to normalize historical or project future prices when possible, especially where the performing contractor business unit is known. However, defense contractors often change their accounting and operations such that a consistent time series of FPRs is difficult to develop. Because these data are sensitive, DCMA houses the FPR information in the gated Contracts Business Analysis Repository[43] system whose access is generally restricted to government personnel on a need-to-know basis.

G. Forecasting resources

The BLS and BEA, considered the authoritative sources for the various escalation rates and inflation rates that they produce, only produce values for historical actuals. When cost analysis requires the use of a price forecast, such as forecasting future costs of a weapon system, analysts do have some sources, both public and private, that they can access to obtain these forecasts.

Examples of public sources for escalation and inflation forecasts include the Congressional Budget Office (CBO), the Office of Management and Budget (OMB), and the Energy Information Administration (EIA). CBO and OMB typically produce forecasts of general inflation, such the GDPPI or the consumer price index, and escalation rates aggregated at a high level, such as the total compensation ECI. Analysts will likely not find forecasts of specific PPIs or ECIs from these agencies. EIA annually produces forecasts of energy and fuel prices, at a relatively detailed level.

There are several private sources of price and inflation forecasts. One private source commonly used in the Department of Defense is IHS Global Insight (IHS). IHS maintains an extensive macroeconomic model that is used to generate forecasts of almost any economic indicator or price index produced by BLS and BEA. Forecasts from IHS are generally available going out 30 years. IHS is commonly used by cost analysts in DoD to obtain a forecast of a specific PPI needed in their analysis (e.g., the PPI for titanium). DoD maintains multiple subscriptions to IHS forecast data, and cost analysts should check with their respective Service cost agency to determine their access.

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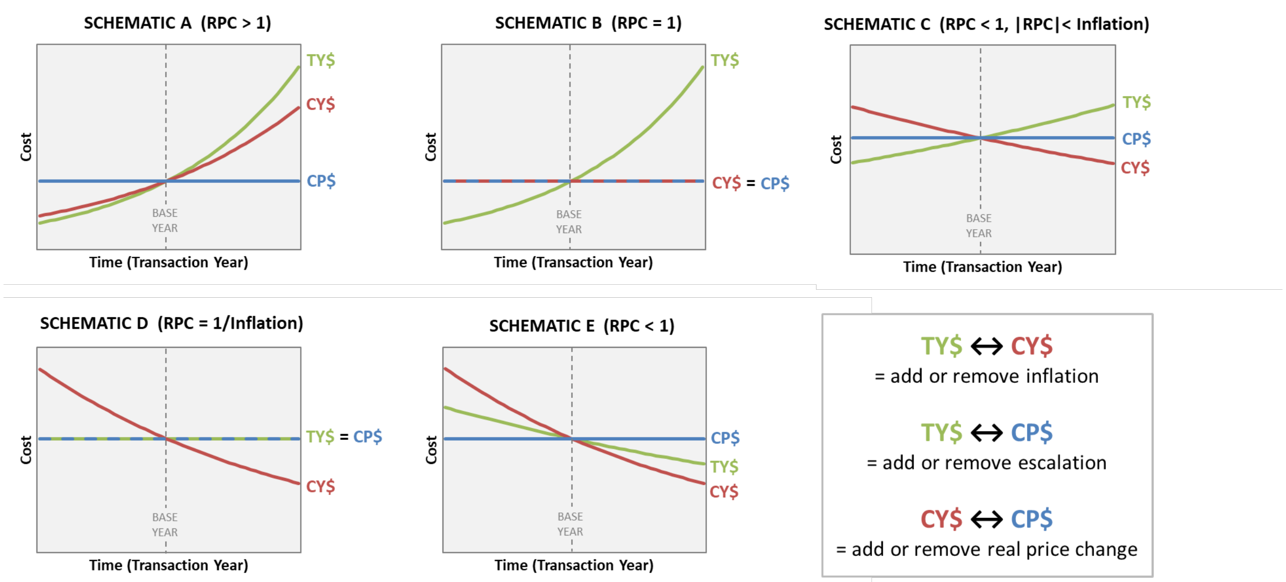
[43] Contract Business Analysis Repository (CBAR). Hosted by the Defense Contract Management Agency. See http://www.dcma.mil/DCMAIT/cbt/CBAR/index.cfm.

Appendix C. Advanced Terminology

Escalation may be positive, zero, or negative; assuming positive inflation (as is typical for the U.S. economy), the rate of real price change determines the appearance of escalation (see Figure C-1). If real price change is positive (RPC > 1; Schematic A), zero (RPC = 1, or the market basket mirrors the entire economy; Schematic B), or negative but smaller in magnitude than inflation (RPC < 1, |RPC| < inflation; Schematic C), escalation will be positive. If real price change is the inverse of inflation (RPC = 1/inflation; Schematic D), escalation will be zero. If real price change is negative (RPC < 1; Schematic E), escalation will be negative. The fact that some of these schematics show lines for CY$ with a downward slope may be surprising to some readers, given that they visualize inflation as a positive force; recall that costs normalized to CY$ are not showing the rate of inflation itself, they are showing the costs when inflation is removed. Therefore, you will always be *removing* a positive value (unless the U.S. economy experiences deflation, or Inflation < 1), not necessarily *obtaining* a positive value as a result; for this reason, the CY$ line is always below the TY$ line but may not have a positive slope.

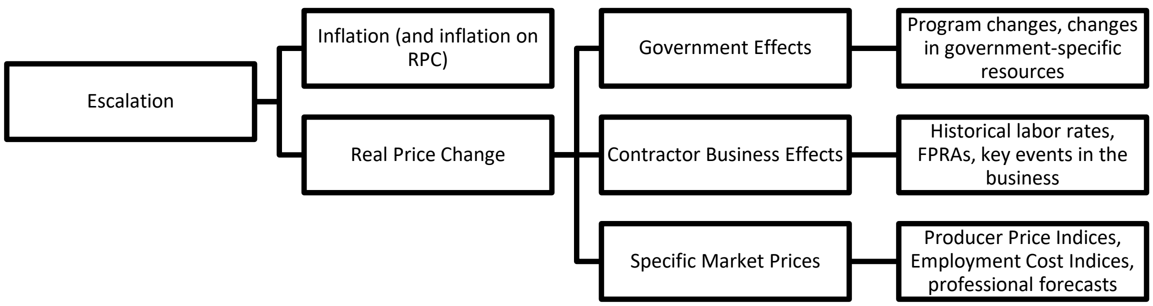
Figure C-1. Dollar type relationships depend on magnitude and sign of RPC.



Appendix D. Advanced Framework Concepts

Figure D-1 illustrates a basic framework for considering the components of escalation from an economist's perspective. This framework organizes real price change drivers based on whether they are government-driven, contractor-driven, or related to the broader market of the product or service in question.

Figure D-1. Economist's framework for analyzing escalation.



A. Specific market price effects

While inflation measures the aggregate change in prices for the overall US economy, an individual item sits within an industry or commodity market which may experience average price changes different from the rate of inflation. Professionally developed price indices are available to track the price changes in many specific markets. For example, if the item of analysis were a missile seeker, you could use the Producer Price Index (PPI) for Search Detection Navigation and Guidance; or if it were a ship, the PPI for Shipbuilding Construction. Refer to Appendix B for a discussion of escalation index resources. Normalizing observed prices using a specific market price index simultaneously removes both general inflation and the real price change related to the specific market. Conversely, applying a specific market price index to a value applies both inflation and real price change. Therefore, you should not consecutively apply an inflation index and a specific market price index to normalize or forecast because doing so would account for inflation twice.

B. Contractor business effects

In addition to the subject of an estimate being associated with a broader industry or commodity group, the particular company or companies that produce items for the estimated program may experience real price change at a different rate than the industry average. You should consider actions a contractor takes, or is expected to take, that affect program cost; for example, a particular company may:

- sell off excess facilities to lower operating costs;
- increase retirement benefits in response to a new pension regulation or competition for qualified labor;
- change its business base (e.g., add or subtract contacts from its overhead pool);
- relocate to a new geographic location;
- reorganize its business units;
- increase or decrease salaries in response to changes in workforce demographics, skill mix, or union agreements; or,
- implement process improvements.

These and other considerations are especially important for firms that have significant pricing power in their industry. You should explore changes that have affected historical costs for the companies represented in your estimate, and the extent to which those factors (and any new ones) will drive costs in the future.

The contractor business effects listed above could affect the contractor's labor rates, or price paid by the government per hour of labor. The fully burdened labor rate includes much of an individual contractor's experience of price escalation, including capital, administrative, and fringe costs. However, external forces other than contractor business effects can also affect labor rates and escalation—goods and services purchased by the contractor are also subject to inflation, specific market prices, the business effects of subcontractors, and government decisions.

Like specific market price indices, indices for contractor labor rates typically include both inflation and real price change. De-escalating observed prices with contractor labor rates removes the effects of inflation as well as elements of specific market price changes, so be careful not to double-count inflation or real price change depending on how you apply any other indices in your estimate.

C. Government effects

The government purchaser controls demand for DoD end items, creating substantial effects on the year-to-year price variation. For example, increasing annual production may induce learning and rate effects which will put downward pressure on the unit cost of an item. The government also negotiates non-quality requirements with the contractors, such as information reporting and other regulations, which affect the price paid. Some other examples of government effects on escalation include:

- Government Furnished Equipment (GFE) and Material (GFM), which become inputs into the contractor's production process, but the contractor does not necessarily determine their sourcing or pricing
- Changes in the government's acquisition policies
- Changes to Working Capital Fund rates
- Pay raises for military service members and government civilians
- Comptroller-dictated fuel prices

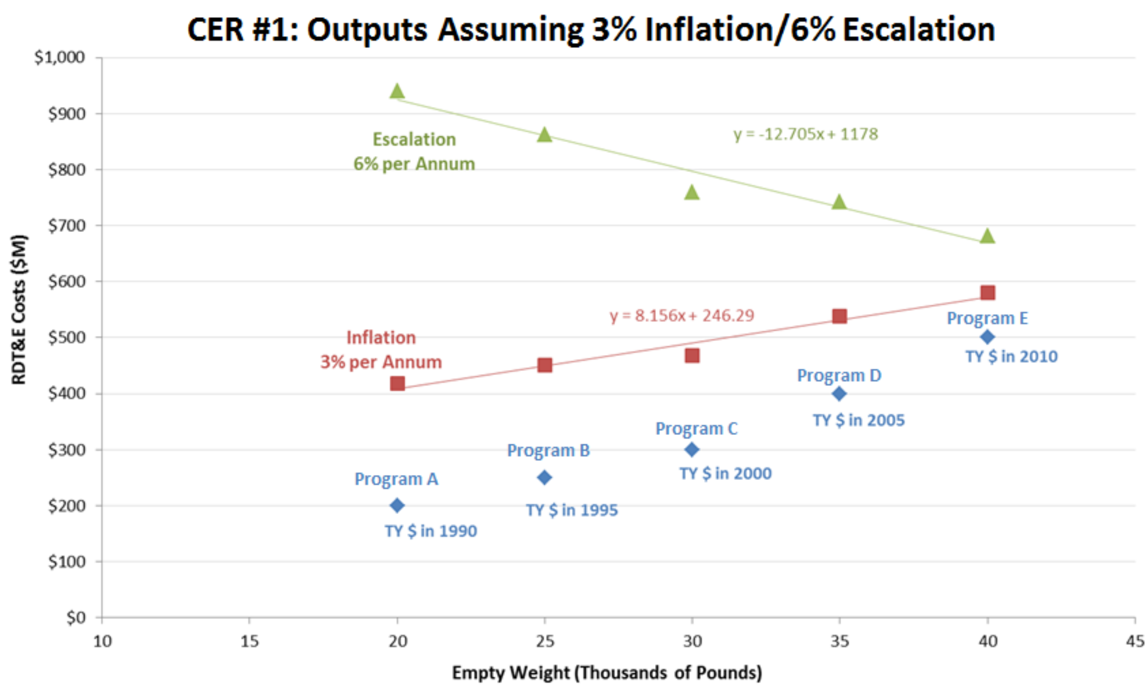
As with the other real price change categories in this framework, some of these considerations may also be attributed to other categories depending on the commodity and structure of the estimate; be careful not to double-count or omit drivers of real price change.

Appendix E. Advanced Output Concepts

A. Intermediate escalation application in CER development

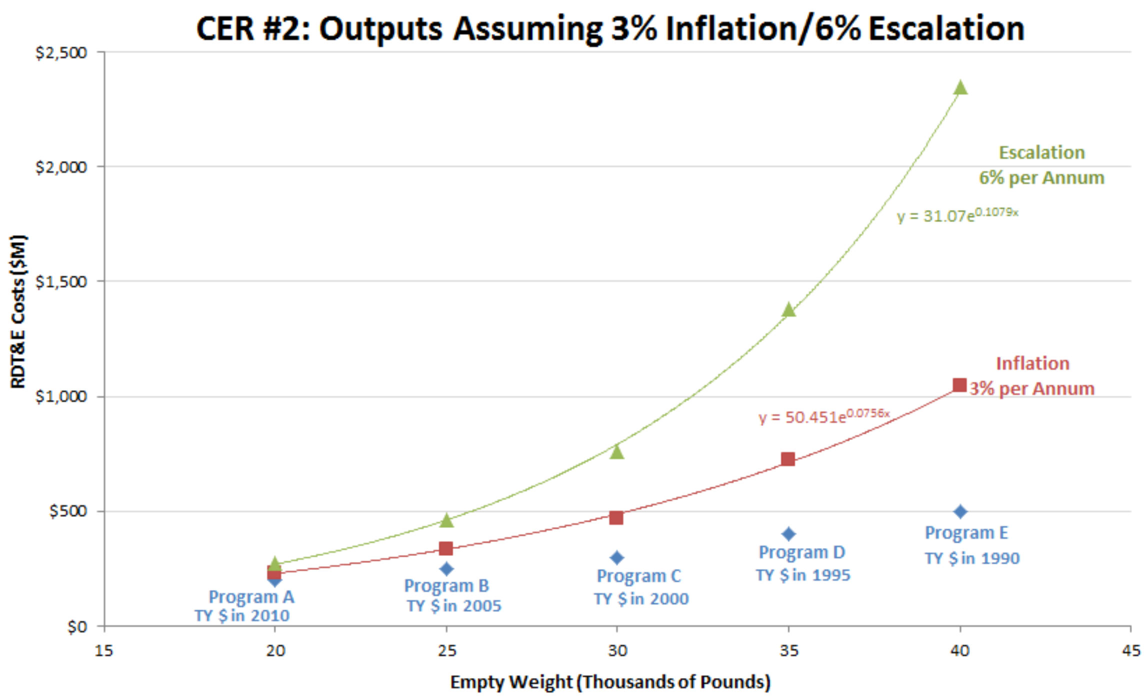
The CER example provided in Chapter 5 section B showed the effect of index selection on the slope of the equation; this appendix will show the same effect when the technical characteristic of interest is also correlated with time. For example, say you want to create a CER that correlates aircraft empty weight with RDT&E costs using data from completed contracts. Data for five analogous programs show that there has been a steady increase in empty aircraft weight over time, with the lightest aircraft developed in 1990 and the heaviest developed in 2010. Figure E-1 below shows the results of building a CER using these data normalized to CY$ (using a notional inflation index of 3 percent per year) compared to the same data normalized to CP$ (using a notional escalation index of 6 percent per year). The same phenomenon could be observed when comparing CERs built using alternative escalation indices (i.e., CP$ normalized to remove escalation of different magnitude).

Figure E-1. CER development when technical characteristic directly correlated with time.



In the above example, the choice of index not only changes the slope, but can also change your qualitative understanding of the relationship: whether cost and the technical characteristic are positively or negatively correlated. Similarly, as shown in Figure E-2 below, the reverse relationship between weight and time makes the relationship appear exponential rather than linear.

Figure E-2. CER development when technical characteristic indirectly correlated with time.



The fact that the index selected affects the coefficients of a CER equation may make the relationships or index selection seem arbitrary, but that is not the case and should not deter you from applying program-specific escalation indices. You can use any equation to get results, and as long as you use a CER that was built in a manner relevant for your estimate—and use the equation in a manner consistent with how it was built—you should obtain a valid result. This also means that when you use a CER that used a particular escalation index to generate its CP$ inputs, you must use the same escalation index to convert the CER output for your program (which will be in CP$ initially) to TY$ for your final cost estimate.

B. Advanced escalation application in CER development

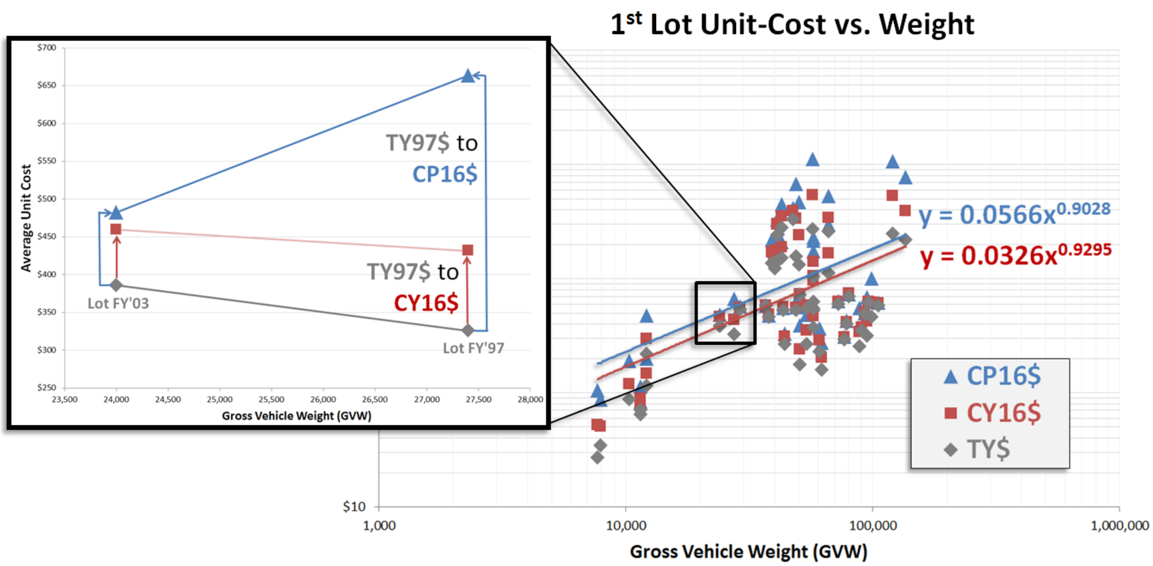
The following section will expand on the basic example from Chapter 5 section B and provide additional information for handling escalation in CER development. Assume that a new ground vehicle has just finished its Engineering and Manufacturing Development (EMD) phase and is authorized to move into its first production lot. The prototype units have a known cost, and the contractor used an engineering build-up method as the basis for their proposal. Your task is to derive an independent cost estimate using a set of historical data on first production lots. For each analogy, the data provided include: year of first lot purchase, total cost, quantity, and five technical characteristics.

The historical production data span nearly 20 years, implying large distortion to the purchasing power of the dollar between programs. In order to explore cost relationships, you must first normalize the data. Per the instructions in Chapter 5 section B, you first normalize the TY$ inputs to CP$ using an appropriate escalation index that is weighted by the outlay profile for the appropriation Weapons & Tracked Combat Vehicles Procurement, Army (WTCV). For comparative purposes, you also normalize the TY$ using an inflation index to return CY$ inputs for the CER, although developing CERs using CY$ is not considered a best practice (as described in Chapter 5).

You decide to create a bivariate CER that correlates the log of first lot unit cost (in both CY$ and CP$) and the log of gross vehicle weight; you put the variables into log space because you expected that a percentage change, as opposed to unit change, in weight would leave to a percentage change in unit cost. If tactical vehicle prices have experienced real price change, these two CER models will differ when estimated in CY$ and CP$. This difference is shown in Figure E-3 below. While the unit costs are higher in CP$ than in CY$, the general relationship between cost and weight is maintained: an increase of 1.00% in weight is associated with a 0.90% increase in CP16$, and a 0.93% increase in CY16$ (see exponents of CER equations in Figure E-3).

The correlation between unit cost and cost driver is not always consistent between CY$ and CP$. In the left-hand chart of Figure E-3, the choice of normalization can result in substantially different views of the prevailing relationship across data subsets. Where the independent variable (weight) has a strong correlation with time, an escalation rate significantly different than inflation can result in estimated relationships of opposite signs (as discussed in the previous section). In such cases, a CY$ CER mistakenly attributes cost variation to the independent variable that which results from real price change (i.e., omitted variable bias). Because there is little correlation between weight and time for the dataset as a whole, the line of best fit has a similar slope for both CY$ and CP$ normalizations. The neglect of real price change is largely absorbed by the intercept term.

Figure E-3. Bivariate Cost Estimating Relationship.



You decide to improve upon your bivariate CERs above by including a number of other important cost drivers which can pick up variation not explained by vehicle weight. For example, a light vehicle may cost more than a heavy vehicle if it had other quality differences, such as a higher maximum speed. Adding other variables as regressors into the parametric analysis allows for such considerations. Figure E-4 below shows the output from a multiple regression on six independent variables. Note how the regression coefficients on weight have changed significantly from the bivariate specification as cost variation was better attributed the other variables. An increase of 1.00% in weight is assocated with a unit cost increase of 0.28% in CP16$ and 0.42% in CY16$. The inclusion of other variables, such as "derivative," affects these changes:vehicles which are derivatives (i.e., not a new design), are associated with CP16$ unit costs ($e^{-0.25}$ = 0.775) 77.5% that of new vehicles, all else equal. In CY16$, derivates are associated with reduced savings as derivate unit costs are only ($e^{-0.14}$ = 0.870) 87.0% that of new vehicles. Also note that the the derivative variable is not statistically significant at the 90% level in the CY$ formulation.

Figure E-4. Multivariate regression coefficients (standard errors) in log-space.

		LN(Constant-Price 16$)	LN(Constant-Year 16$)	LN(Then-Year)
Technical Characteristics	LN[GVW (lbs)]	0.28 (0.09)***	0.42 (0.09)***	0.54 (0.1)***
	LN(Max speed)	-2.35 (0.28)***	-1.45 (0.29)***	-0.78 (0.32)**
	Combat (Dummy)	1.28 (0.13)***	1.18 (0.14)***	1.01 (0.15)***
	Armored (Dummy)	0.77 (0.13)***	0.89 (0.14)***	0.97 (0.15)***
	Derivative (Dummy)	-0.25 (0.13)*	-0.14 (0.13)	-0.02 (0.14)
Learning/Rate Effects	LN(Cum. Quantity)	-0.09 (0.03)***	-0.11 (0.03)***	-0.12 (0.03)***
	INT	13.06 (1.75)***	7.5 (1.84)***	3.26 (2.01)*
"Goodness of Fit" Measure	R-Squared	91.5%	89.6%	86.8%
	Predicted Unit Cost	$3,008	$2,292	$1,626

*** = Significant at **99%** Confidence Level
** = Significant at **95%** Confidence Level
* = Significant at **90%** Confidence Level

Using the regression coefficients from the CER models, you can predict the first lot unit cost of the future program. Assume the following:

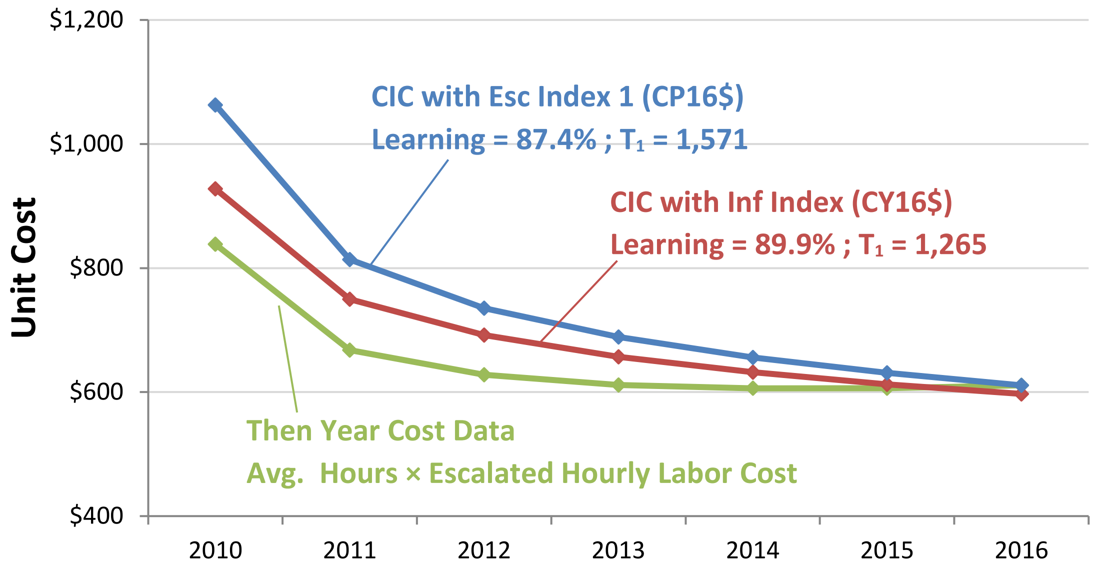
- **Work Start:** 2018
- **First Lot Quantity:** 60 units
- **Gross Vehicle Weight (GVW):** 50,200 lbs
- **Max Speed:** 62 MPH
- Is **armored**; is **combat**; is a **derivative**

Applying the CP$ coefficients, the unit cost is CP16 $3,008. Applying the CY$ coefficients, the unit cost is CY16 $2,292. Though the outputs are in different units (one in CP$ and the other CY$), the estimates are equivalent to TY$ if it is assumed that the first production lot were obligated in the base year (here, BY16); in this case, the CP16$ CER would estimate the average unit cost for the first lot of the new program to be 31% higher than the result of the CY16$ CER. However, since the work is assumed to start in 2018 using the WTCV appropriation outlay, you multiply the CER results by the 2018 value from the BY16 weighted escalation (for CP$ CER) and inflation (for CY$ CER) indices. The final TY$ results in 2018 are $3,216 and $2,361, showing a greater delta between the two methods of 36% due to the anticipated real price change captured in the CP$ CER.

C. Agreement between perfect-CP$ CICs and Learning Curves

Note that in Figure 5-8, the estimated learning slope for the CP$ CIC agreed with the slope of the learning curve using hours. The T_1 costs also agree, though the units have different denominations. Using CY$, both the estimated learning and T_1 cost are less because the price of labor grew faster than inflation. As a result, the CIC in CP$ found a dollar in the past bought relatively more labor hours than CIC in CY$. More implied hours in the past means the program experienced relatively steeper (greater) learning. Figure E-5 below shows a plot of the analogous data set in TY$ (green). It also shows the fitted, or regression derived, values from a CIC produced with the "ideal" escalation index provided (CP16$, blue) and from a CIC produced with an inflation index (CY16$, red).[44]

Figure E-5. Analogous data fitted values.



The coefficients from the analogous learning models can also be used to predict the new program's costs in both CY$ and CP$. The predicted values from the regression models, which remain in base year 2016 dollars, are still expressed in different types of dollars: one model is in CP16$ and the other is in CY16$. The predicted costs for the new program are displayed in Figure E-6 below, and shown relative to the predictions from the learning curve (based on hours) in TY$ in purple.

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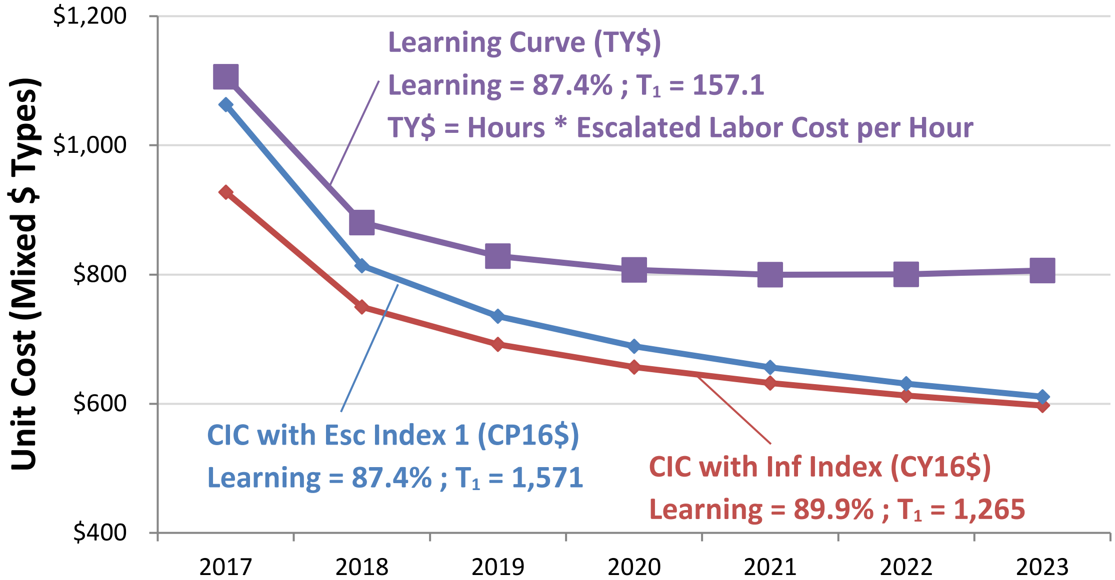
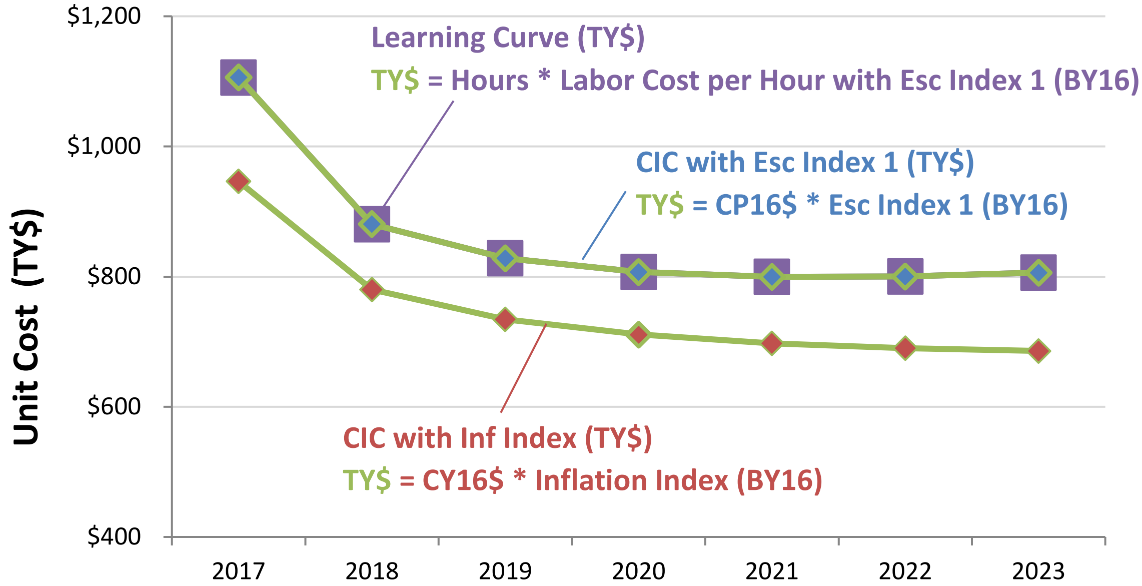
44 A further indication that the CY$ CIC is problematic is that the red curve does not pass through the actual 2016 value, despite the "perfected" data concocted for this example.

Figure E-6. Predicted values for new program.



The final step is to convert predicted costs to TY$. This is done by applying the projected inflation index values to the CY$ and the projected escalation index values to the CP$ for 2017-2023 (see Figure E-7 below). Note that the estimate performed using the CIC built with Escalation Index 1 agrees with the learning curve built using hours. This complete agreement exists because labor costs alone were targeted and perfect information regarding escalation was assumed (i.e., Escalation Index 1 was used, which was derived from the labor rates directly, rather than a more generic index such as Escalation Index 2). The inflation model, on the other hand, underestimated unit costs relative to the learning curve by more than 10 percent.

Figure E-7. New program final then year cost estimates.



In the case where an analogous historical program is used to estimate a future program, the inflation model (after inflation is reapplied) will produce TY$ which preserve much the same slope relative to the escalation model (after escalation is reapplied). The slope is largely preserved because the regression in CY$ seeks to produce a mean bias of zero over the relevant quantities. However, the inflation model's TY$ costs fall below the escalation model's because it neglects the real price change that has occurred between the analogous program and the new.

Appendix F. Policy and Guidance

There are instructions at various levels from OMB down to the Services that address how inflation should be incorporated into cost estimates and budgets. This section discusses these instructions and how to interpret them through the lens of cost estimation.

OMB A-11 and issuances from the OUSD(Comptroller) (OUSD(C)) and Service comptrollers are relevant to determining the top line for budgeting for each appropriation. They also ensure that mandatory programs (such as pay and benefits for military and civilian employees) are funded according to law. Cost analysis is intended to be an accurate representation of what a particular system will cost. This point is reinforced by most budget guidance. Decision-makers typically use the estimated costs of systems to determine how to spend available funds, to identify potential shortfalls, and to make decisions about programs.

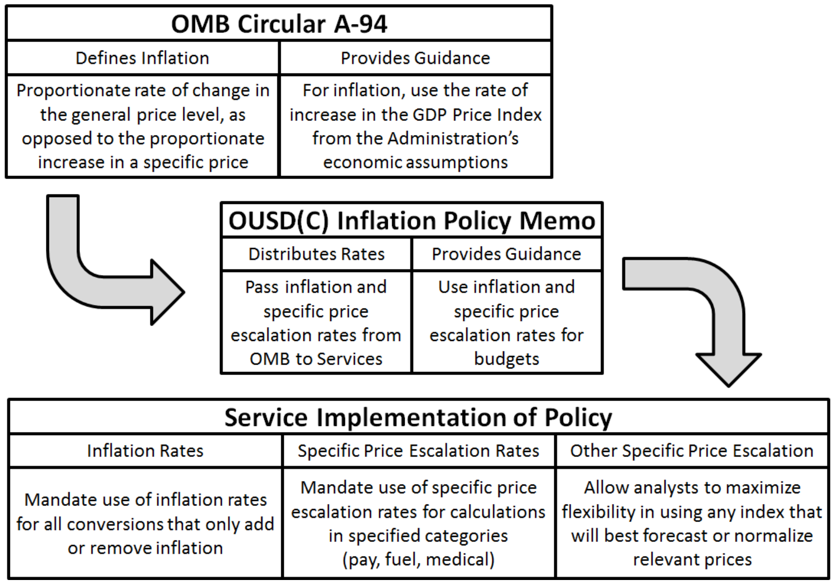
While some of the guidance is complex and can be contradictory, the law states unambiguously that the Department must build realistic cost estimates. This theme is echoed in the instructions from OMB using the less clear wording “Full rate of anticipated inflation.” In our terminology, this means anticipated escalation. The guidance in the DoD FMR has wording that both constrains programs to use OUSD(C)-provided indices and requires analysts to include the most likely or expected full growth in costs. Ultimately, analysts are required by law to develop realistic estimates as required by WSARA, which will require the use of indices that include both inflation and real price change.

Most cost estimators use price indices developed and published by a DoD organization, such as a financial management branch or a cost estimating shop. This chapter outlines how the DoD develops price indices. It will help the analyst distinguish between inflation and escalation indices, regardless of how they are labeled, and thereby help the analyst select an appropriate index for a given analysis.

A. Overview

Figure F-1 below provides an overall perspective of the chain of inflation and escalation policy and guidance. High level guidance and the administration’s economic assumptions are provided by OMB. OUSD(C) converts the GDPPI into rates and provides those rates along with selected specific price escalation indices to the Services. OUSD(C) also mandates use of the rates they provide for budget purposes. The Services then build indices from the rates and otherwise implement the guidance provided by OUSD(C) while allowing flexibility in forecasting so analysts can perform realistic cost estimating.

Figure F-1. Chain of policy.



B. Pricing guidance for the President's Budget

Three Executive Branch offices work together to develop economic forecasts to include a forecast of the Gross Domestic Product Chain-Weighted Price Index (GDPPI): the Office of Management and Budget (OMB), the Department of the Treasury, and the Council of Economic Advisers (CEA), informally known together as the "Troika." Federal agencies, including the Department of Defense, use the GDPPI forecast as the inflation forecast for planning purposes and when preparing budget documents. The economic assumptions are recorded in Table 10-1 of the OMB historical tables.[45]

[45] https://www.whitehouse.gov/omb/historical-tables/

OMB provides the inflation forecast to OUSD(C), which uses the forecast as the basis for many of the price growth rates published in its annual "Inflation Guidance." The congruence between the GDPPI and the Inflation Guidance for the President's Budget is shown in Figure 17 on the right. Within the guidance, annual rates are the same for: RDT&E; Procurement; Military Construction; O&M (excluding fuel and medical); and Military Personnel (non-pay excluding medical accrual). These rates are the same because they all reflect the GDPPI, which OUSD(C) publishes every year in Table 5-1 of the "Green Book."

Figure F-2. Source of inflation guidance and select escalation guidance.

Table 5-1: DEPARTMENT OF DEFENSE AND SELECTED ECONOMY-WIDE INDICES
(Base Year = 2016)

Fiscal Year	Gross Domestic Product[1]	Consumer Price Index (CPI-W)[2]	Dept of Defense Non-Pay	Dept of Defense Purchases[3]	Total Department of Defense
2010	90.65	88.89	89.93	90.73	90.91
2011	92.42	91.56	91.97	92.37	92.71
2012	94.03	93.94	93.63	93.88	94.22
2013	95.67	95.44	95.36	95.30	95.80
2014	97.12	96.88	96.74	96.75	97.04
2015	98.44	98.14	98.36	98.28	98.49
2016	100.00	100.00	100.00	100.00	100.00
2017	101.79	102.10	101.95	101.89	101.75
2018	103.76	[illegible]			
2019	105.84	[illegible]			
2020	107.96	[illegible]			

1. From OMB Historical Table 10-1 (Gross Domestic Prod[illegible]
2. Provided by OMB.
3. Excludes pay, fuel, and medical factors.

Year	GDPPI	Rate
2013	95.67	
2014	97.12	1.5%
2015	98.44	1.4%
2016	100.00	1.6%
2017	101.79	1.8%
2018	103.76	1.9%
2019	105.84	2.0%
2020	107.96	2.0%

- **OMB publishes the GDPPI**
- **OSD re-publishes it in the Green Book (above)**
- **OSD converts index to rates**
- **OSD publishes rates as inflation guidance (right)**

Inflation Guidance - FY 2016 President's Budget

PRICE ESCALATION INDICES
(Annual Rates in Percentages)

Fiscal Year	Proc	RDT&E	Mil Con[1] FH Con	O&M (Excl Fuel and DHP)	Fuel	Mil Pers[2] Non-Pay (Excl Med Accrual)	CPI-U Medical
	OUTLAYS						
2014	1.5	1.5	1.5	1.5	-2.9	1.5	2.3
2015	1.4	1.4	1.4	1.4	2.2	1.4	2.7
2016	1.6	1.6	1.6	1.6	-7.3	1.6	3.6
2017	1.8	1.8	1.8	1.8	-1.7	1.8	3.8
2018	1.9	1.9	1.9	1.9	0.9	1.9	3.9
2019	2.0	2.0	2.0	2.0	0.9	2.0	3.9
2020	2.0	2.0	2.0	2.0	0.9	2.0	3.9

The rate guidance provided by OUSD(C) contains price escalation rate guidance for fuel, medical, and government employee pay, in addition to inflation. Like inflation, OUSD(C) receives this guidance from the Troika and provides it to the Services.

C. OMB Circular A-11

OMB Circular A-11 is entitled "Preparation, Submission, and Execution of the Budget." [46] Section 31 specifically provides instruction on how to prepare and submit materials required to formulate the President's Budget (PB).

Section 31.1(a) addresses what should be used as a basis for a budget proposal. The circular states that "In developing the estimates, consider the effect that demographic, economic, or other changes can have on program levels beyond the budget year."

Section 31.1 (c) addresses the proper economic assumptions to use when developing estimates to be used in the "out years" (the nine years following the budget year). This sub-section states that "OMB policy permits consideration of price changes for goods and services as a factor in developing estimates. However, this does not mean that you should automatically include an allowance for the full rate of anticipated inflation in your

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[46] https://www.whitehouse.gov/omb/information-for-agencies/circulars/

request." In this paragraph, OMB appears to be calling the price change of a particular good or service the "full rate of anticipated inflation." This would be what we would term "escalation."

In the following citation from the same sub-section, OMB requires that "mandatory programs" (e.g., social security, government personnel retirement) in the out years are funded for the entire anticipated price change. OMB sees these programs as existing liabilities that must be paid and as such, the entire price increase must be considered.

> "For mandatory programs, reflect the full inflation rate where such an allowance is required by law and there has been no decision to propose less than required."

Conversely, the next citation shows that the OMB allows the Department more flexibility in discretionary programs by allowing the out years to include the full anticipated price increase or something less than the full anticipated price increase. Ultimately, the Department must make decisions among its competing discretionary priorities in order to produce a budget that is consistent with the budget planning guidance levels. (Remember, the ultimate goal of this circular is to facilitate budget preparation.)

> "For discretionary programs, you may include an allowance for the full rate of anticipated inflation, an allowance for less than the full rate, or even no allowance for inflation. In many cases, you must make trade-offs between budgeting increases for inflation versus other increases for programmatic purposes. Unless OMB determines otherwise, you must prepare your budget requests to OMB within the budget planning guidance levels provided to you, regardless of the effect of inflation."

Failure to provide for the full rate of anticipated inflation implies buying less of the item in question. This is allowable for discretionary programs, but not for mandatory programs.

D. OMB Circular A-94

OMB Circular A-94 "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs"[47] provides general guidance for conducting benefit-cost and cost-effectiveness analysis. As such, it includes a definition for inflation and recommended inflation assumptions for both within the Future Years Defense Program (FYDP) and forecasting beyond the FYDP.

The OMB definition for inflation is as follows.

[47] https://www.whitehouse.gov/omb/information-for-agencies/circulars/

> "Inflation[48] - The proportionate rate of change in the general price level, as opposed to the proportionate increase in a specific price. Inflation is usually measured by a broad-based price index, such as the implicit deflator for Gross Domestic Product or the Consumer Price Index."

This definition includes the widely agreed upon concepts for the economic definition of inflation that one would find in any reputable textbook. The important understanding is that inflation is the change in the general price level and not the change in the specific price of any particular good.

OMB's recommended inflation assumptions are as follows.

> "When a general inflation assumption is needed, the rate of increase in the Gross Domestic Product deflator from the Administration's economic assumptions for the period of the analysis is recommended. For projects or programs that extend beyond the six-year budget horizon, the inflation assumption can be extended by using the inflation rate for the sixth year of the budget forecast."

E. Weapon Systems Acquisition Reform Act of 2009 (WSARA)

Title 10 USC Section 2334 "Independent cost estimation and cost analysis" was created by WSARA.[49] It emphasizes that indices used by the Department of Defense meet the needs for realistic cost estimating. This means that the best information available should be used to build Then-Year estimates. As such, analysts should not apply an index that they believe will not provide a complete picture of the anticipated cost. Instead, analysts should seek out the best available tools to estimate the future cost of their program. The following citation from this section highlights this point.

> (a) IN GENERAL.—The Director of Cost Assessment and Program Evaluation shall ensure that the cost estimation and cost analysis processes of the Department of Defense provide accurate information and realistic estimates of cost for the acquisition programs of the Department of Defense. In carrying out that responsibility, the Director shall …
>
> (7) periodically assess and update the cost indices used by the Department to ensure that such indices have a sound basis and meet the Department's needs for realistic cost estimation;…."

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[48] The use of "Full rate of anticipated inflation" in OMB Circular A-11 does not convey the same meaning as the more traditional definition of inflation included in OMB Circular A-94. By adding the language "full rate of anticipated," the authors of OMB Circular A-11 include the complete price change (escalation), not just inflation.

[49] https://www.law.cornell.edu/uscode/text/10/2334

F. DoD FMR Volume 2A Chapter 1

The guidance in DoD 7000.14-R, the Department of Defense Financial Management Regulation (DoD FMR)[50] Volume 2A can be contradictory from the perspective of a cost analyst. Consistent with WSARA, section 010303.B.1 of the DoD FMR requires "most likely, or expected cost."

> "It is DoD policy to reflect the most likely or expected full costs (including military and civilian personnel pay) for the current year, the biennial budget years, and outyear estimates for all appropriations."

However, the DoD FMR then specifies that estimated price level changes will be based on data provided by OUSD (Comptroller). Comptroller does not distribute specific guidance on the anticipated price level changes of individual programs, but the guidance says the indices provided by Comptroller will be updated as economic conditions warrant.

> "[This] estimated price level changes will be based on data provided by OUSD (Comptroller). These indices, which will be updated as economic conditions warrant, will be used to (1) determine the amount of price escalation for a procurement line item, major RDT&E system, or construction item over a given time period, and (2) project inflation in other noncompensation areas of all other appropriations."

In section 010303.B.4, the DoD FMR goes on to say that the budget estimates for goods and services will reflect such things as learning curves and specific price changes:

> "Biennial budget estimates for goods and services will in all cases reflect the following considerations: …
>
> b. The state of development or production and the learning curve.
>
> c. Specific price changes, to take effect at a future date -- e.g., a specific and authoritative rate or tariff schedule to take effect on a definite future date, which may involve higher or lower prices than those in effect at the time estimates are prepared."

Finally, under section 010107 Budget Terminology/Definitions, the definition for Current Service Estimates explicitly states that inflation should not be the only basis for the budget estimate. This means that the budget estimate should include the entire expected price increase of a good or service.

> "Current Services Estimates: Estimated budget authority and outlays for the upcoming fiscal year based on continuation of existing levels of service... These estimates of budget authority and outlays, accompanied by the underlying economic and programmatic assumptions upon which they are based (such as the rate of inflation, the rate of real economic growth,

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[50] http://comptroller.defense.gov/FMR.aspx

pay increases, etc.), are required to be transmitted by the President to the Congress."

G. OUSD (Comptroller) annual inflation guidance

OUSD (Comptroller) annually produces guidance on inflation, fuel, medical and government employee pay raise assumptions. The guidance may be a bit confusing because it is labeled inflation guidance, but it also includes price indices for fuel, medical, and pay raises. Figure F-3 shows the guidance distributed for the FY16 President's Budget.[51] You can see in the figure that the growth rates for Procurement, RDT&E, Military Construction, O&M, and Military Personnel Non-Pay are all the same. That is because these are equal to inflation. The remaining rates are specific price escalation rates.

Figure F-3. Annual Comptroller memo (rates page).

Inflation Guidance - FY 2016 President's Budget

PRICE ESCALATION INDICES
(Annual Rates in Percentages)

Fiscal Year	Proc	RDT&E	Mil Con[1] FH Con	O&M (Excl Fuel and DHP)	Fuel	Mil Pers[2] Non-Pay (Excl Med Accrual)	CPI-U Medical
OUTLAYS							
2014	1.5	1.5	1.5	1.5	-2.9	1.5	2.3
2015	1.4	1.4	1.4	1.4	2.2	1.4	2.7
2016	1.6	1.6	1.6	1.6	-7.3	1.6	3.6
2017	1.8	1.8	1.8	1.8	-1.7	1.8	3.8
2018	1.9	1.9	1.9	1.9	0.9	1.9	3.9
2019	2.0	2.0	2.0	2.0	0.9	2.0	3.9
2020	2.0	2.0	2.0	2.0	0.9	2.0	3.9
BUDGET AUTHORITY[3]							
2014	1.6	1.5	1.6	1.5	-2.9	1.5	2.6
2015	1.7	1.5	1.8	1.6	2.2	1.4	3.1
2016	1.8	1.7	1.9	1.7	-7.3	1.6	3.7
2017	1.9	1.9	2.0	1.9	-1.7	1.8	3.8
2018	2.0	2.0	2.0	2.0	0.9	1.9	3.9
2019	2.0	2.0	2.0	2.0	0.9	2.0	3.9
2020	2.0	2.0	2.0	2.0	0.9	2.0	3.9

PAY RAISE ASSUMPTIONS[4]

Fiscal Year	ECI[5]	Military	Civilian
2014	1.8	1.0	1.0
2015	1.8	1.0	1.0
2016	2.3	1.3	1.3
2017	-	1.3	1.3
2018	-	1.5	1.5
2019	-	1.5	1.5
2020	-	1.8	1.8

1. Use for Chemical Demilitarization Construction, Defense-Wide.
2. Not to be used to inflate accounts fixed by statute.
3. These are composite rates at the P.L. title level. Inflation rates for specific accounts are a function of their spendout profiles and will vary within each title. DWCF activities use these rates for non-pay inflation.
4. Pay raises are effective January 1 of each year.
5. Employment Cost Index; for use in setting the by-law (37 U.S.C. 1009) military pay raise.

[51] https://www.ncca.navy.mil/tools/FY2017_PB_Inflation_Guidance.pdf

The Annual Comptroller Inflation Guidance includes not only rates but also outlay profiles from which the weighted indices are built. Figure F-4 shows some of the outlay profiles distributed for the FY16 President's Budget. For a detailed explanation on how weighted indices are constructed using an outlay profile, see Chapter 7 section E. While that use case is intended to address escalation indices, the mechanical calculations are the same for inflation. One important note is that the outlay rates exclude pay and fuel dollars (as is documented at the top of each outlay profile page in the memo). This means that the weighted indices developed using these outlay profiles do not include pay and fuel. Since pay and fuel do not commonly experience price escalation beyond the year of appropriation, they should be adjusted using the raw index.

Figure F-4. Annual Comptroller memo (outlay rates page).

Outlay Rates To Be Used For Incremental Changes in BA Purchases

(As Percent of BA Purchases; Excludes Pay and Fuel Dollars)

	FIRST YEAR	SECOND YEAR	THIRD YEAR	FOURTH YEAR	FIFTH YEAR	SIXTH YEAR	SEVENTH YEAR	EIGHTH YEAR	NINTH YEAR	TENTH YEAR
Military Personnel										
Army	79.51	17.24	3.25							
Navy	85.16	11.87	2.97							
Marine Corps	81.45	18.55								
Air Force	83.86	16.14								
Army Reserve	67.16	21.78	11.06							
Navy Reserve	75.76	24.24								
Marine Corps Reserve	78.94	21.06								
Air Force Reserve	77.93	22.07								
Army National Guard	70.96	29.04								
Air National Guard	84.33	15.67								
Operation and Maintenance										
Army	28.94	53.30	13.15	1.95	2.66					
Navy	48.25	39.72	8.20	2.19	1.64					
Marine Corps	34.68	51.65	11.28	2.39						
Air Force	41.46	43.78	10.25	2.61	1.90					
Defense-Wide	49.00	42.55	4.87	2.15	1.43					
Inspector General	32.22	61.00	3.39	3.39						
Army Reserve	39.14	46.25	9.89	3.04	1.68					
Navy Reserve	55.41	38.64	2.68	2.23	1.04					
Marine Corps Reserve	48.05	38.69	8.84	3.32	1.10					
Air Force Reserve	45.17	46.06	5.48	1.32	1.97					
Army National Guard	49.20	40.02	6.93	1.69	2.16					
Air National Guard	53.05	38.25	3.48	2.26	1.22	1.74				
Overseas Contingency Ops	60.00	25.00	10.00	3.50	1.50					
Court of Appeals, Armed Forces	57.22	31.33	7.13	4.32						
Drug Interdiction	43.44	49.52	5.15	1.89						
Defense Health Program	62.34	25.02	11.05	1.59						
Environmental Restoration	40.00	40.00	15.00	5.00						
Overseas Humanitarian	15.70	26.90	32.00	15.00	7.00	3.40				
Cooperative Threat Reduction	5.00	50.00	22.00	13.50	9.50					
Procurement: Army										
Army Aircraft	9.70	40.20	28.80	15.40	2.70	1.10	1.10	1.00		
Army Missiles	7.20	35.80	30.60	18.00	5.60	1.70	0.50	0.60		
Army W&TCV	6.30	31.90	31.40	21.10	5.80	2.30	0.50	0.70		
Army Ammunition	6.70	35.70	34.60	13.20	4.40	2.50	1.80	1.10		
Army Other	12.10	42.90	29.00	7.00	4.00	3.00	1.00	1.00		
JIEDDO	16.60	51.40	22.30	4.70	3.00	1.00	1.00			
Chemical Agents and Mun	40.00	30.00	15.00	8.00	4.00	2.00	1.00			
Procurement: Navy										
Navy Aircraft	14.50	34.00	32.00	9.00	4.00	3.00	2.00	1.50		
Navy Weapons	18.00	30.20	26.50	12.80	6.50	3.50	1.50	1.00		
Navy & MC Ammunition	8.30	32.40	29.30	16.00	7.00	4.00	2.00	1.00		
Navy Shipbuilding	8.40	24.40	19.50	16.70	12.00	9.00	6.00	2.00	1.00	1.00
Navy Other	20.50	42.10	21.10	7.30	4.50	2.00	1.50	1.00		
Procurement, Marine Corps	13.00	42.00	27.20	10.90	3.50	1.40	1.00	1.00		

Beginning in 2020, OSD CAPE released an addendum to the above memorandum that recommended outyear escalation rates for certain cost elements such as military pay and fuel.