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Getting Real: Price Deflation of Nominal Values

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Abstract

It is often useful to convert nominal values to real values for applied welfare analysis. This article discusses the use of price deflators, and several published economic indices that may be useful for this process.

KEYWORDS: price deflators, price indices

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It is often useful to convert nominal values to real values for applied welfare analysis. Comparison of real values, such as for wages, prices, or revenues, enables evaluation in terms of dollar amounts that have equivalent purchasing power. In determining present value, the analyst must match real values to a real discount rate; or nominal values to a nominal discount rate (Zerbe and Bellas 2006; Boardman et al. 2000). In benefit-cost analysis, it is recommended that the analysis be undertaken using either entirely nominal values with a nominal discount rate, or entirely real values with a real interest rate. The U.S. guidelines for regulatory analysis appear to implicitly recommend conducting the analysis in real terms, by supplying official U.S. discount rates that are adjusted for inflation (U.S. OMB 2003, 33-34). Similarly, in the U.K. the official discount rate is a real discount rate of 3.5% (HM Treasury 2010, 98). Real interest rates can be approximated by subtracting expected inflation from the nominal interest rate.

Econometric analysis of time series and panel data usually uses real, rather than nominal values of the economic variables. Economic agents are often assumed to predicate their decision making on the basis of real data (for example real income and real wages, which represent the true purchasing power of a worker's earnings). In econometric estimation, one approach to alleviating multicollinearity among prices is by converting nominal prices to real prices, particularly in a multimarket analysis. This reduces the effect of prices in different markets moving together over time, and focuses empirically on differences in price changes among the markets (Just et al. 2004).

There are several published economic indices that may be used for converting nominal values into constant-dollar values. In the U.S. the most frequently used measures are those produced by the U.S. Bureau of Labor Statistics (BLS) and the U.S. Bureau of Economic Analysis (BEA). BLS price indices are objective measures, constructed from data by statistically rigorous methodologies, and, in the case of the Consumer Price Index (CPI) and Producer Price Index (PPI), are based on measurement objectives defined by economic theory. As summarized by the BLS website: "Various indexes have been devised to measure different aspects of inflation. The CPI measures inflation as experienced by consumers in their day-to-day living expenses; the Producer Price Index (PPI) measures inflation at earlier stages of the production process; the Employment Cost Index (ECI) measures it in the labor market; the BLS International Price Program measures it for imports and exports; and the Gross Domestic Product Deflator (GDP Deflator) measures inflation experienced by both consumers themselves as well as governments and other institutions providing goods and services to consumers." (U.S. BLS 2010a). The GDP deflator is produced by the BEA, as is the Personal Consumption Expenditures Deflator (PCE deflator) and the gross domestic purchases price index, which

encompasses the scope of the PCE as well as domestic private investment, and government spending (U.S. BEA 2010a). Most other nations have their own conceptual counterparts of these price index measures, and some empirical measures have been developed specifically to enable international comparisons (e.g., purchasing power parities).

The choice of the appropriate price index for deflation depends upon the economic variable under consideration. The U.S. CPI, PPI, and ECI are often used as escalators in contracts to adjust payments made in future periods for changes in purchasing power since the reference period. The CPI is the measure most often used in economic analysis since it reflects inflation as experienced by U.S. consumer households. To construct a measure of real wages, for example, analysts usually deflate nominal wage values by the CPI. In benefit-cost analysis, where an assumption of general inflation is needed, the U.S. OMB recommends using the GDP deflator (U.S. OMB 2010, 8), but, in practice, the Consumer Price Index (CPI) is used to determine a real discount rate (U.S. OMB 2003, 33-34).

The Mechanics of Escalation and Deflation

Using a price index, such as the CPI, as an escalator involves answering the question: “How much would be needed as a payment in period c to enable the purchase of the same market basket purchased in reference period r ?” In general, escalation is accomplished by multiplying the cost of a market basket in period r by the ratio of comparison and reference period CPI measures where the latter are in the same base period.¹

Conversely, in using a price index as a deflator to convert a nominal value to a real value, one multiplies a market basket valued in the comparison period by the ratio of the CPI in period r to the CPI in the comparison period c .²

For most applications it is recommended that one not use the seasonally adjusted index value. This is for several reasons, not the least of which is that previously published seasonally adjusted index values are subject to revision (U.S. BLS 1998). If the base periods for CPI_c and CPI_r differ, then one should normalize one of them so that they share a common base. If the two periods r and c are far apart in time, one should bear in mind that the market baskets in the two

¹More precisely, r will denote the reference period, c denotes the comparison period, and both index values CPI_r and CPI_c have a common base period b (i.e. $CPI_b = 100$). Defining R as the cost of the market basket in period r , CPI_c is the price index value in period c , CPI_r is the value of the price index in period r , and C_r^* is therefore the desired escalated, or real, payment in period c . Escalation would be accomplished by the following equation: $C_r^* = R(CPI_c/CPI_r)$.

² Specifically, deflation would be accomplished by $R_c^* = C(CPI_r/CPI_c)$, where R_c^* is the value of period c 's payment in terms of period r 's purchasing power, and is thus the “real” value from the period r perspective.

periods may be so very different that the economic interpretation of a price change measure may be a bit dubious (e.g., while the U.S. CPI series ranges from 1913 to the present, it would be difficult to compare the goods and services available to consumers in 2010 to those available in 1913).

The U.S. Consumer Price Index

The U.S. Consumer Price Index is the flagship measure of inflation in the U.S. economy. The construction of the index is a complex process, involving aggregation of individual observations of prices at several levels, with sampling and weighting using several databases (see U.S. BLS 2008a). The BLS publishes three CPI data each month: (a) the CPI for all urban consumers (CPI-U), which usually serves as the “official” number reported by the press; (b) the CPI for urban wage earners and clerical workers (CPI-W), which covers a demographic subset of the CPI-U; and (c) a chained CPI for all urban consumers (C-CPI-U). The CPI-U and CPI-W are, essentially, modified Laspeyres price indices, while the more recent C-CPI-U, introduced in 2002, is constructed as a superlative index. In terms of economic theory, the Laspeyres formula is the price index counterpart to the compensating variation which, in welfare analysis, corresponds to “willingness to pay.” Generally, the Laspeyres formula is as follows:

$$L(p_r, p_c, x_r) = \sum (p_c^n / p_r^n) \cdot s_r^n,$$

where p_r^n is the reference period price of good n , p_c^n is the comparison period price of good n , and s_r^n is the share of total expenditures spent on good n in the reference period, and there are goods $n=1, \dots, N$ in the market basket. In terms of economic theory, this index is an upper bound on the “true” cost-of-living index (see Fixler 1993, 5).

The superlative index, which underlies the C-CPI-U, has been proven to more closely approximate the “true” cost-of-living index, which is the theoretical measurement objective of a price index in many applications. By taking the geometric mean of period r and period c market baskets of goods and services purchased, it ameliorates the problem of substitution bias, which occurs because consumers can substitute among goods and services as their relative prices change (i.e., they can move along an indifference curve in response to relative price changes). Since a superlative index requires information on expenditure shares in the current period, the C-CPI-U is published with a time lag and is subject to revision.

Unlike some other measures of inflation, such as the GDP deflator, the CPI intends to measure price changes for the consumption of goods and services by households. This excludes investment goods, income taxes, and government

services. In order to separate the investment component from the flow of services consumed from a durable good, a “rental equivalence” procedure is used for owner-occupied housing. The CPI also differs from the PCE deflator, produced by the U.S. Bureau of Economic Analysis (U.S. BEA) to deflate the personal consumption expenditures component of the National Income and Product Accounts. While the PCE deflator incorporates some of the BLS’s CPI price information, it also includes expenditures by the military, museums and libraries, among other expenditures out of the scope of the CPI, and, unlike the Laspeyres-based CPI-U, it has been based on the superlative Fisher ideal index formula since 1997. The Fisher ideal index satisfies the product test, and thus the PCE deflator can be obtained by dividing the ratio of expenditures by a Fisher ideal quantity index (Fixler and Jaditz 2002, 8). In practice it often differs empirically, if by small amounts, from the U.S. CPI-U.

In addition to the all-items CPI series, the BLS also publishes detailed index series by commodity category, region, and some urban areas. The geographic area-specific indices provide indicators of inflation for specific areas, but, because they are based on smaller samples of data, they may not have the statistical precision of the overall CPI. They are also not useful for making comparisons of price levels between areas at any point in time (see last section of this article). Although there has been much research on CPI series for specific demographic groups, such as the elderly (Amble and Stewart 1994) and the poor (Garner et al. 1996), no such indices are published officially because of lack of statistical significance in the estimates derived from existing data.

The U.S. Producer Price Index

The U.S. Producer Price Index (PPI) can be described in economic terms as a fixed-input output index, and averages changes in prices received by domestic producers for their output. It is also calculated as a Laspeyres formula. It covers domestic mining and manufacturing, agriculture, fisheries, forestry, utilities, and construction (U.S. BLS 2008b). The Finished Goods Index is the flagship aggregate index reported by the BLS each month. It is often viewed as a predictor of the CPI, but the two indices do not share the same scope. The Finished Goods PPI does not include the service sector, and it encompasses only domestic production, not imported goods or services.

For analysis of specific markets, the indices produced by the Producer Price Index program of the BLS may be useful in their more detailed levels. These include price indices for 500 production sector categories and 4,500 indices for specific products and categories, and more than 1,000 indices in the services sector, as of January 2007 (*ibid.*, 1). The PPI program uses the NAICS classification system, which replaced the SIC system in 2004. The BLS

recommends using the stage-of-processing index subseries in economic analysis because this classification structure minimizes the problem of multiple counting (i.e. multiplying of a single price change at the lowest level of the production process up through that process to the finished good) (ibid., 15).

The PPI for capital equipment is used as a component in the GDP deflator by the U.S. Commerce Department (ibid., 18).

The U.S. Employment Cost Index

The U.S. Employment Cost Index (ECI) is a measure of compensation costs for U.S. civilian workers, and includes both wage and salary components as well as employer-provided benefits. It is constructed from data collected by business establishments in the National Compensation Survey (NCS) (U.S. BLS 2010b). Thus, it can be used as an escalator for labor costs in the business sector. In addition to the flagship index, there are more disaggregate series by occupation, industry, region, and some metropolitan areas. The ECI series dates back to 1976.

Detailed information on these indices is provided on the BLS website (U.S. BLS 2010b), including the methodological process, the underlying theoretical bases for the index formulas, data sources, weights, sampling, and precision of the index estimates. Press releases of current statistics, historical tables of index values, and research papers are also available.

The U.S. GDP Deflator

The GDP deflator is produced by the U.S. Commerce Department, and is the implicit price deflator for goods and services produced in the United States (gross domestic product).³ It differs from both the CPI and the PCE deflator because it measures price changes for domestic production, while the latter measure prices changes for domestic consumption including the direct and indirect effects of price changes in imported goods and services that are consumed in the United States (U.S. BEA 2010a).

The GDP deflator is an implicit price index and is also a chained index. It is obtained by calculating the ratio of the current dollar value of GDP to its corresponding chained-dollar value, multiplied by 100. A chained-dollar value is “a measure used to approximate the chained-type index level and is calculated by taking the current dollar level of a series in the base period and multiplying it by the change in the chained-type quantity index number for the series since the base period” (U.S. BEA 2010b). In general, a chained index series is one constructed

³ Gross domestic product replaced gross national product (GNP) as a measure of U.S. production in 1991.

by multiplying each period-to-period index number in series from the base period to the comparison one, as shown below:

$$I_{0,t} = I_{0,1} * I_{1,2} * I_{2,3} * \dots * I_{t-1,t}$$

where I is any index, period 0 is the base period, and period t is the comparison period.⁴

The GDP deflator may be found in the BEA's National Income and Product Accounts (NIPA), Table 1.1.9 (U.S. BEA, 2010a).

International Consumer Price Indices

Most nations produce economic statistics on price changes, particularly consumer price indices. Although the detailed statistical methods and market basket sampling may differ, most countries' CPIs are fundamentally Laspeyres indices in concept. Among the member nations of the Organization for Economic Cooperation and Development (OECD), all have Laspeyres CPIs and some (France, Sweden, Norway, and the United Kingdom) update their expenditure weights annually, far more frequently than the United States does. The OECD provides detailed information on their members' CPIs in a comprehensive document on their website, *OECD Main Economic Indicators (MEI)—Sources and Methods: Consumer Price Indices* (OECD 2010d).

Because every nation uses a different market basket and its own statistical methodology for the specific components of its price indices, it is difficult to compare inflation rates across nations in a quantitative sense (Lane and Schmidt 2006, 20). There is, however, sometimes a need to have comparable measures of price change for several countries, such as when twelve European nations in the European Union adopted a common currency, the euro. To meet this need, the statistical agency Eurostat mandated that each member nation produce a harmonized index of consumer prices (HICP), comparable across the countries. The HICP series often is produced as a complement to each nation's own internal CPI (*ibid.*, 21). Researchers at the U.S. BLS have produced an experimental HICP series from U.S. CPI data and compared it empirically to the official European HICP. This study did provide an indication that these indices tracked each other rather well (Lane and Schmidt 2006). Future research may provide more such empirically useful comparisons.

⁴ In practice, any index formula may be chained, including the Laspeyres CPI, but the chaining process makes it difficult to compare the index to its theoretical measurement objective (e.g., the true cost-of-living index), and can also introduce some problems when price changes are volatile in both positive and negative directions (chain drift) (see, e.g., Aizcorbe and Jackman, 1993).

Inter-Area Price Level Comparisons

The price indices described above are inter-temporal; that is, they measure price change over time. It is not possible to use city-specific U.S. CPI series to compare price levels in different cities at any point in time, nor to use a comparison of international CPI values to derive information on differences in price levels between countries. For example, in January 2010 the CPI for the Los Angeles metropolitan area was 224.6, and the CPI for the Chicago metropolitan area was 212.1. Since both index values have a base period of 1982–1984 (average)=100.0, this means that prices rose 124.6% in Los Angeles and 112.1% in Chicago over that period. Thus, while prices increased relatively more rapidly in the former than the latter, there is no information on whether price levels were higher or lower in one city versus the other in any period, including the base period. If, hypothetically, prices in Chicago were twice those for Los Angeles in 1982–1984, then Chicago would still be the more expensive city in which to live in 2010. At present, the U.S. BLS does not produce official indices that could be used empirically to compare price levels across areas, although there has been research on this subject (Aten 2006; Kokoski et al. 1999).

There are at least two nongovernmental organizations that produce inter-area price comparisons data. One is Runzheimer International, which provides custom comparisons of living costs between select areas, mainly for corporate clients in need of this information for relocation. The other is ACCRA, which provides, by subscription, comparative price data across 300 cities. The aggregated geographic cost-of-living comparison produced by ACCRA is for the specific demographic group of “professional, managerial households in the top income quintile” (Council for Community and Economic Research 2010).

Internationally, price statistics that enable comparison across countries are provided by the OECD in the form of purchasing power parities (PPPs). These PPPs are “currency conversion rates that both convert to a common currency and equalize purchasing power of different currencies. In other words, they eliminate the differences in price levels between countries in the process of conversion.” (OECD 2010a). The OECD and Eurostat share responsibility for calculating these statistics, and the data used are collected specifically for this purpose (and thus may not correspond to data collected by each nation for its own CPI). The main purpose of the PPPs is as a “first step in making inter-country comparisons in terms of real GDP and its components” (OECD 2010b), and while about 2500 consumer goods and services categories are included, each participating country may only provide price relatives for a few hundred categories that are in common with the other countries.

A complex statistical methodology is used to aggregate these price relatives, and the reference for the comparison among countries is not a single

country but, rather, the geometric mean of all the countries compared (see OECD 2010c). This aggregation method, known as EKS, is used because it has the favorable statistical property of consistency in aggregation, and avoids the Gerschenkron effect, which results from the correlation between prices and volumes (the substitution effect) (OECD 2010b).

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