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Consumer Price Indices, International Trade Indices and Producer Price Indices

Introduction

National accounts series are compiled from data from economic surveys which are expressed in terms of prices of the period for which they are collected. Increases or drops in national accounts series, like the gross domestic product, are the result of price changes and volume changes. The main use of national accounts series, such as GDP GNI, is to show how an economy is growing or contracting. Economic growth of an economy can best be analysed with constant price series that are adjusted for price effects.

This paper reviews recent developments in the area of consumer price indices, in particular, and also covers international and producer price indices. Most of the issues are discussed in the context of consumer price indices, but they apply to other Laspeyres type price indices as well.

Consumer Price Indices (CPI)

The Boskin Report¹ criticised the U. S. consumer price indices saying that, “The strength of the CPI is the underlying simplicity of its concept: pricing a fixed (but representative) market basket of goods and services over time. Its weakness follows from the conception: the fixed basket becomes less and less representative over time as consumers respond to price changes and new choices”. The Boskin Report’s best estimate for the upward bias of the CPI was 1.1 percentage points per annum in 1996. Of this, 0.6 percentage point was due to inadequate handling of new products and problems in adjusting for quality change in existing products. The upward bias created an annual automatic increase in indexed benefits and a real tax cut.

An overstatement or understatement of the CPI can:

¹ Boskin, M. J. et al (1996)

1. Adversely affect government expenditure, receipts, the welfare of citizens who may be getting pensions and social security checks that are indexed to the CPI.
2. Lead to poor policies by government and monetary authorities. For instance, monetary authorities may adopt deflationary policies believing that the rate of inflation is high.
3. Adversely affect the financial viability of private companies bound by escalation clauses in their contracts.

The Boskin Report has provided a major impetus to research in the area of price indices to the US statistical agencies and other national statistical agencies, since the agencies use similar methodology to compile indices.

Methodology for the Compilation of CPI

The CPI measures changes in prices paid by consumers for consumption of goods and services. CPI does not cover all household expenditures, it excludes investment, saving and transfers. A consumer expenditure survey is conducted in the base year. It is from this survey that the proportion of income spent on various expenditure categories is determined. These proportions become weights for the sample items of prices that are collected in each expenditure category. Typical categories of household expenditure can be as follows:

- Food and non alcoholic beverages
- Alcoholic beverages and tobacco
- Clothing and footwear
- Housing, water, electricity and gas
- Furnishings and household equipment
- Health
- Transport
- Communication
- Recreation and cultural services
- Hotels, cafes and restaurants
- Miscellaneous goods and services

Most national statistical offices use the Laspeyres formula to compute the CPI, which is given by the formula:

$$I_{t0} = \frac{\sum (P_{it}Q_{i0})}{\sum (P_{i0}Q_{i0})}$$

P_{it} is the price of the i^{th} sample item in year t

P_{i0} is the price of the i^{th} item in the base year

Q_{i0} is the quantity of the i^{th} item consumed in base period

Consumer price indices are calculated for different groups of households with similar expenditure patterns, for example in India there is a CPI for industrial workers (IW), a CPI for agricultural labourers, a CPI for rural workers and a CPI for urban non-manual employees. Each of these categories of households will consume different amounts or types of goods, so the weight of categories of expenditure like food, clothing and so on will be different for the different households. The CPI for high-income earners contains different goods in the sample from those in the sample for the CPI for low-income earners. The CPI can be compiled on a weekly, monthly, quarterly or annual basis. In periods of hyperinflation it might be necessary to compile the CPI weekly. Some countries change the base period annually while others change the base period every five years, some change after more than five years. Rural households are frequently excluded because of the high cost of price collection. In most countries the institutional population is left out, although it is part of the household sector in national accounts.

Item Substitution

Some of the issues that are common in Laspeyres type CPI compilation are (a) Seasonal items in the CPI sample and (b) Quality adjustment.

There are two ways to treat seasonal items during non-priced periods:

1. the price of goods is imputed by carrying forward the last observed price until the item becomes available again
2. impute the price change of the expenditure group.

(B) Quality adjustment and item substitution as pointed out in the Boskin Report are big problems in CPI compilation. Item substitution may occur due to changes in fashion, tastes, income, and technology. There can also be substitution of outlets where consumers purchase products.

Quality adjustment is difficult for statistical agencies to carry out, because it can not be done mechanically in a routine way; each quality change requires individual attention. CPI staff are often put in a situation where they have to make subjective judgement about the extent of quality change, and statistical agencies are uncomfortable making such judgements.

One criterion for choosing the method to be employed for quality adjustment is the funding level and organisational structure of a statistical agency. When a new product replaces an old one, and there isn't enough information on which to base a quality adjustment, an agency may find it too expensive to use hedonistic regression techniques, and therefore may decide to allocate 50% of the price change to quality change. Such a rule of thumb may be useful where quality adjustments are made by price collectors in the field and not at the CPI headquarters.²

Direct quality adjustments are made to prices of cars and trucks to take into account quality differences between old and new models. The reason why so much research in the area of price indices has focused on sample item substitution and quality adjustment is that they account for most price increases. Thus, quality adjustment is very important to the accuracy of the CPI. In the US CPI for 1983, 1984 and 1995, price observations involving replacement items accounted for less than four percent of all price observations, but they accounted for a great majority of the annual index change³. During quality adjustment,

² see for example, Hoffman (1999)

³ Greenlees (1999) page 2

Statisticians identify the proportion of the upward increase in prices that is the result of change in quality, thus reducing the upward bias of the indices like the CPI that are Laspeyres based. Quality changes in cars include structural or engineering changes that affect safety, reliability, performance, durability, economy, manoeuvrability, comfort and convenience. The adjustment is based on either the previous model's retail price for optional equipment or is obtained from production cost data supplied by the manufacturer.

The CPI field staff or CPI headquarters isolate important price-determining characteristics of CPI sample items. These characteristics are held constant, and the following formula is used to impute the cost of the new car model:

$$P_{i,t-1}^* = P_{i,t-1} + QA$$

Where: $P_{i,t-1}$ is the actual previous price of the previous item
QA is the value of the quality change

$$P_{i,0}^* = (P_{i,0} P_{i,t-1}^*) / P_{i,t-1}$$

Where: $P_{i,0}^*$ is the base year price for the new item.
 $P_{i,0}$ is the base year price for the previous item.

In the case of food items, there are frequent non-comparable substitutions. Usually, one assumes the price change for a missing sample item is the same as the average price of similar items in the CPI.

A number of countries are using hedonic regression to adjust for quality, and even data from electronic scanners in supermarkets can be used in this type of regression. Hedonic regression can be used where there are frequent fashion changes as is the case of clothes and shoes for ladies. Hedonic regression modeling is a tool that allows a researcher to isolate the most important price-determining characteristics of these goods. It works well

for consumer goods, improving the accuracy in the adjustment process. For example, in USA the Bureau of Labour Statistics has used hedonic regression to adjust for quality change in television sets because of frequent technological improvements that render older models obsolete. The procedure decomposes the price of television sets into implicit prices for each important feature and component. The procedure facilitates the replacing of obsolete televisions in the CPI sample with current ones allowing the CPI to capture price change that may occur as new models replace old ones in the market place while adjusting for quality changes.

The characteristics that are used in quality adjustment are: screen size, wide screen, liquid crystal, projection, surround sound, console, picture-in-picture (one tuner), picture-in-picture (two tuners), number of video inputs, brand group, learning/universal remote and free delivery. There was a large and significant co-efficient for brand group. Brand may be proxy for unmeasured characteristics like quality of manufacturing⁴.

Another example of hedonic regression is from Finland, in their CPI: the index for used cars is based on 70 regression equations where there is one equation for each of the 70 popular car models.

Log(asking price) is explained by

- age of the car
- mileage
- its price as new
- time dummies for the 5 preceding months
- minor corrections for area price difference.

A weighted Laspeyres index is calculated using monthly chaining (Hykko (1999)).

⁴ Fixler *et al* (1999) and BLS Handbook of Methods

The French have found hedonic analysis to work particularly well when used to adjust for quality changes for dishwashers in CPI. A central team manages nation-wide replacements of sample items.

Most consumer durable goods last for years when we buy them, but since new technology is coming up all the time, many models are for sale for only 1 to 12 months before they are replaced with new products. Bascher & Lacroix (1999) report that the sample of consumer-durable items is often entirely replaced during the year, and some products are even replaced several times a year.

This undermines the “fixed-basket” conception of the CPI.

In their model, the dependent variable is the price level and the model is linear and there are 333 observations. There are eleven variables and the intercept representing the reference situation: three quantitative variables (water consumption, power consumption and the number of programs) and eight dichotomous variables divided into four groups: sales outlet, noise level, delayed start and brand reputation. The adjusted R^2 was equal to 0.86. The model was a good fit, see appendix 1 for regression estimates.

Treatment of Changes in Quality in SNA93 Manual

The Manual recommends that the observed price be adjusted for quality change or the two qualities should be regarded as separate goods and to estimate their prices in periods in which they are not sold. Quality adjustment can be carried out using hedonic regression procedures where feasible.

International Trade Price Indices

International Trade Price Indices measure price changes of imports and exports. They can be compiled using three different classifications: Harmonized System, End-Use Classification and Standard International Trade Classification (SITC) Rev.3. International Price Indices are used to deflate exports and imports. The indices classified by end-use can

be used in demand analysis or to deflate exports and imports for national accounts purposes.

In the case of USA, respondents provide prices of actual transactions as close as possible to the first day of the month. For intra-company transfers, only market-price transactions are accepted. Average prices are used for some commodities like petroleum, ocean tanker freight and grains data.

Trade factors associated with each item include country of origin/destination, the discount structure, class of buyer or seller and for imports, the amount of duty. Import prices are quoted free on board (f.o.b.) while export prices are on free alongside ship (f.a.s.) When a new item is added to a classification grouping, the relative importance of each item in the classification group is redistributed to include the new item and the historical movement of the indices is used to begin the series for the item.

International price indices are Laspeyres type just as in the case of CPI

International indices are used in elasticity studies. One can calculate price and income elasticities to determine how much of trade volume changes are attributable to price effects and how much to income effects. Manufacturers can also use these indices to assess their competitiveness.

Producer Price Indices (PPI)

PPI measure price change from the perspective of the seller, where as CPI measures price change from the perspective of the consumer. Producers' and consumers' prices may differ due government subsidies, sales and excise taxes and distribution costs. They can be compiled monthly, quarterly or annually.

Producer price indices are usually calculated using Laspeyres type index formula. PPI are used to deflate economic series such as inventory, sales, shipments, and capital equipment replacement costs. Private business firms use PPI in escalation clauses to protect both buyer and seller from unanticipated surges or drops in prices. They can compare changes in prices of their inputs to changes in PPI for that material.

The weights for categories in PPI come from economic censuses, PPI covers output from all industries, mining, agriculture, fishing, forestry gas and electricity. PPI can be expanded to cover services as well.

PPI measures net revenue accruing to a specified producing establishment for a specified product shipped under specified transaction terms on a specified day of month. It excludes revenues collected on behalf of government but includes low-interest financing plans and other sales techniques. Transaction prices and not list prices are used.

In the case of the USA, to carry out quality adjustment in PPI, data on costs incurred by reporting companies with the quality change are collected. Sometimes quality adjustment is carried out using the “overlap” method when the old and new items are on sale in the same time period. Hedonic regressions can also be used for quality adjustment of high-tech consumer items.

Computers and semiconductors give problems because quality improvements are often larger than price increases. Quality adjustment is done using a hedonic model that decomposes the price of personal computers into implicit prices for each important feature and component of the computer. The procedure has been used to adjust for quality in prices of desktop computers since 1990. In regressions for the desktop, the explanatory variables are chip type, chip speed, amount of system memory, video memory, hard drive capacity, sound system, modem, monitor type and size, type of operating system software, type of office suite software, Local Area Network (LAN) ready and manufacture group⁵.

⁵ reported in Fixler *et al* (1999)

Bias in the CPI

The Boskin Report criticised the US consumer price index for its bias, which comprises of substitution bias, new goods bias, quality change bias and new outlets bias. The criticism applies to other countries' CPI as much as to the US CPI. Thus all national statistical agencies have taken the criticism seriously.

Bias is usually defined as the deviation of the CPI from a Cost of Living (COL) index. Bias includes neither sampling nor non-sampling errors, for those are not systematic in nature. The Laspeyres formula that is used to calculate CPI uses base weights that become out of date in time. The Paasche Index on the other hand uses current weights, data for which are not yet available. The Fisher ideal index uses weighting information for both periods and is symmetric, however data on weights from the current weights may not be available. Erwin (1976) has shown that the Fisher index most closely approximates an exact cost of living index for any utility function.

Simple adjustments in quality lead to bias because any absolute change in price is often missed; thus quality adjustment bias is often in CPI and similar price indices. The extent of quality adjustment bias is a matter of judgement. New product bias is given by the extent that an index's sample does not include new products. Outlet substitution bias occurs when consumers will switch from high to lower cost outlets. Upward outlet substitution bias occurs when compilers do not accept the shift from higher to lower priced outlets. In most cases an accurate estimation of bias is very difficult.

As time goes by and prices go up, households switch to cheaper goods, this substitution effect, implies that a fixed Laspeyres index overestimates price changes. Bias is present in the CPI, PPI, international trade indices and the other indices when the Laspeyres formula is used. A Laspeyres price index will be upward biased because it gives big weights to those prices that have risen relatively quickly. The extent of the substitution bias can be obtained from the difference between the Fisher ideal index and the Laspeyres

index. Over more than two periods, theory suggests that a chained Laspeyres index will be lower than fixed base Laspeyres index but higher than the Fisher ideal index.

To overcome problems with bias discussed above, some countries, Italy for example, have begun to compile a Laspeyres chain index for the CPI (see Mostacci & De Iorio 1999). The chain index requires more data, for the weights are updated annually. Another disadvantage of the chain index is the bouncing effect, which is due to the one-year lag between price and quantity used for weights. Another disadvantage is the non-additivity of the chain index, so that it is not easy to compute the contribution of sub-index to the overall index.

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Appendix 1

Hedonic Model for dishwashers

The dependent variable is the price level and the model is linear. The following results are obtained from 333 observations from December 1997. There are eleven variables and the intercept representing the reference situation: three quantitative variables (water consumption, power consumption and the number of programs) and eight dichotomous variables divided into four groups: sales outlet, noise level, delayed start and brand reputation. The adjusted R^2 was equal to 0.86. The model was a good fit.

Variable Type	Description	Coefficient	Student's T
.	Number of Programs	120	8.397
Sales outlet	Hypermarkets and specialised store	Reference	.
	Department store	250	3.012
	Conventional stores	251	6.359
.	Water consumption	-54	-4.64
.	Power consumption	-606	-4.416
Delayed start	Without	Reference	.
	With	248	5.296
Noise level	Very noisy	-284	-5.427
	Average noise	Reference	.
	Low noise	735	11.413
Brand reputation	General class	Reference	.
	Fair	350	5.051
	Good	475	5.188
	Very good	1764	21.653
.	Model intercept	5195	24.607

Source: Bascher, J. & Thierry Lacroix, "*Dishwashers and PCs in the French CPI: hedonic modeling, from design to practice*"