Volume Title: The Measurement of Durable Goods Prices

Volume Author/Editor: Robert J. Gordon

Volume Publisher: University of Chicago Press

Volume ISBN: 0-226-30455-8

Volume URL: http://www.nber.org/books/gord90-1

Conference Date: n/a

Publication Date: January 1990

Chapter Title: Weighting the Alternative Data Sources into New Price and Output Measures for Producer and Consumer Durable Equipment

Chapter Author: Robert J. Gordon

Chapter URL: http://www.nber.org/chapters/c8320

Chapter pages in book: (p. 519 - 560)

12 Weighting the Alternative Data Sources into New Price and Output Measures for Producer and Consumer Durable Equipment

12.1 Introduction

The preceding chapters of this book have developed a large body of new data on the prices of durable goods. On the basis of more than 25,000 new price observations, unduplicated price indexes were constructed for 105 different product categories of producer durable equipment, seventy-five from the Sears catalog (sixty-eight in chap. 10, and the remaining seven in chap. 7), fourteen from *Consumer Reports* (*CR*), eight from unit value data, and eight from other diverse sources. This chapter asks the most important question of all. What does it mean? What is the time series behavior of the deflator for aggregate PDE and for consumer expenditures on durable goods implied by these new data? What are the implications for the growth rate of real investment and the real capital stock in the postwar period? While this chapter describes many of the details involved in aggregating the data, the basic principle is simple. I attempt to use existing NIPA weights for the product categories within PDE, so that differences between the new PDE deflator and the NIPA deflator for PDE will reflect the new data sources but not differences in weighting methods. For individual products within the twenty-two categories of PDE, I adhere tightly to the NIPA weighting scheme (except for the weighting of computers within the office equipment category, as already discussed above in chap. 6). However, to aggregate PDE across the twenty-two categories, the final deflator is based on the Törnqvist method rather than the BEA's implicit deflator method, in light of the undesirable features of the latter also discussed previously in chapter 6. An alternative aggregation of this new information using the implicit deflator method with 1972 and 1982 used as alternative base years is displayed for contrast.

The relatively small share of PDE investment in total GNP immediately enters an important qualification for the discussion of this chapter. No matter how radical the new deflators for producer durable goods may seem, they refer to only a small part of GNP. Even though durable goods prices have increased much less and real investment much more than in the NIPA, this does not imply that the economy-wide inflation rate or real growth rate are significantly biased. Such a conclusion would require a much broader study. A substantial component of consumer spending, the dominant component of GNP, would seem to be immune from the quality adjustment problems that have been the main focus of the book. Price indexes for lettuce, canned fruit, many types of apparel, gasoline, and many other consumer goods are probably quite accurate over the postwar period, if not before. The main questions about consumer spending, other than durables, concern services where there may have been an unmeasured improvement or deterioration. The task of examining consumer services deflators is explored in a separate research project (Baily and Gordon 1988). Pending further evidence, then, I emphasize here that the conclusions of this book should not be taken to apply to any other component of GNP besides durable goods themselves.

Also at this point I should stress the self-imposed limits on the questions asked in this, the final chapter of the book. The aim is to convert the individual product price series into new durable goods deflators. By dividing these new deflators into the existing nominal spending series, a new real investment series is obtained in a straightforward fashion. The resulting real investment series implies new measures of the real capital stock of PDE. In order to expedite publication of these results, I have chosen not to engage in an extensive investigation that uses the new data to redo past studies of the sources of economic growth. As we shall see, the growth rate of the new deflators differs substantially from the NIPA deflators throughout the postwar period, and the implications of these results for the behavior of the investment/output and capital/output ratio are more important than explaining changes in productivity growth from one segment of the postwar era to another.

12.2 Coverage of the Study

12.2.1 Sources of the Official PDE Deflator

The primary focus of this chapter is on the task of weighting together the new product indexes to create a new deflator for PDE. The study has been organized around the twenty-two group categories of PDE, as listed in table 12.1. The basic document from which the study begins is the list, reproduced in Appendix A, of PPIs for individual commodities and groups of commodities used by the BEA in the deflation of PDE. The research agenda was simply to assemble alternative sources of price data for as many of these specific PPIs as possible. When I began the study, the entire PDE deflator in the NIPA was based on components of the PPI, except for three indexes from

Table 12.1 **Shares of Covered Products in PDE by Data Source, 1967 Weights**

	Shares in Nominal PDE			Weight of Alternative Source by Category					
	1947 (1)	1967 (2)	1983 (3)	Sears Catalog (4)	*Consumer Reports* (5)	Unit Value (6)	Energy Adjusted (8)	Not Energy Adjusted (8)	Uncovered (9)
Office, computing	4.0	5.9	10.2	31.5	0.0	0.0	0.0	58.2	10.3
Communications	4.6	7.7	11.0	1.7	3.3	0.0	0.0	95.0	0.0
Instruments*	2.6	4.8	7.3	50.7	2.8	0.7	0.0	0.0	55.0
Fabricated metal	3.3	2.6	3.3	60.8	0.0	5.7	24.7	0.0	8.9
Engines, turbines	0.7	1.5	0.6	15.2	0.0	43.6	25.1	0.0	16.1
Metalworking	5.3	8.7	4.3	77.1	0.0	0.0	0.0	0.0	22.9
Special industry*	7.9	6.5	7.3	61.6	15.7	3.0	0.0	0.0	19.7
General industrial	6.6	6.1	5.0	80.1	0.0	0.0	0.0	0.0	19.9
Electric	5.3	5.9	4.0	70.1	0.0	0.0	0.0	0.0	29.9
Trucks, busses*	11.3	9.0	7.3	0.0	0.0	50.0	50.0	0.0	0.0
Automobiles	11.9	8.5	6.7	0.0	0.0	0.0	100.0	0.0	0.0
Aircraft	0.7	4.6	3.7	0.0	0.0	0.0	100.0	0.0	0.0
Ships*	4.0	1.1	7.7	41.6	0.0	26.9	0.0	0.0	31.5
Railroad	4.0	3.3	0.4	0.0	0.0	0.0	100.0	0.0	0.0
Furniture, fixtures	4.6	4.2	4.4	61.2	0.0	0.0	0.0	0.0	38.8
Tractors	3.3	3.1	2.1	8.1	0.0	0.0	0.0	76.5	15.4
Agricultural	4.6	4.1	2.6	54.9	0.0	0.0	0.0	0.0	45.1
Construction	3.3	3.5	2.6	52.3	0.0	0.0	0.0	0.0	47.7
Mining*	1.3	1.1	1.5	52.3	0.0	0.0	0.0	0.0	47.7
Service industry	6.6	3.9	2.5	25.9	51.9	10.0	0.0	0.0	12.2
Electric n.e.c.	1.3	0.9	2.3	26.7	14.3	0.0	0.0	0.0	59.0
Other*	2.7	3.0	3.2	58.1	0.0	0.0	8.8	0.0	33.2
Total	100.0	100.0	100.0	37.6	4.0	6.3	18.5	10.4	23.2

Source: App. B tables.

Note: Categories denoted with an asterisk are not part of the sixteen categories covered by the detailed tables of App. B. Alternative deflators were used in these categories when they matched the PPIs used for the PDE deflator in these categories, or under other special circumstances. See text and app. to chap. 12.

outside sources (the Civil Aeronautics Board—now Department of Transportation—index of aircraft prices, the Maritime Administration index of ship prices, and the AT&T telephone plant index). Other than these three, the PDE deflator is based on a large number of PPIs, 147 on the list in Appendix A, which covers most of the postwar period.[1] This number exaggerates somewhat the variety of independent PPIs included in the PDE deflator, for fifteen of the 147 are PPI group indexes that are averages of individual product indexes that are entered separately, and eleven of the 147 represent an index that appears twice or, in one case, three times in the count. The correct count of independent PPIs in the Appendix A list is 121. When the study was almost completed, I received a more recent exhibit of PPIs used in 1986; the number displayed had fallen from 147 to 121, including duplications and group indexes.[2] The new list also incorporates two additional sources of information beyond the PPIs, the BEA's price index for computer systems discussed in chapter 6 above, and the CPIs for new and used automobiles examined in chapter 8.

Compared to the 121 unduplicated PPIs in Appendix A, this study has compiled 105 independent product indexes. Of these, the fourteen *CR* indexes overlap fourteen Sears catalog indexes for the same product, and I choose only one or the other for use in the final averages, not both, reducing the number of products covered to ninety-one. Nevertheless, the number of products covered is of the same general order of magnitude as in the PDE deflator. To fix terminology for expositional purposes, in the detailed tables of Appendix B and in the description that follows, I call the new indexes the "alternative" series and those presently making up the PDE deflator the "official series"; in this usage, the word *official* refer not only to the individual PPIs but also the small number of additional data sources used in the PDE deflator, including the BEA computer index. The "official" deflator for a category of PDE (say, metalworking machinery) does not necessarily correspond to the PDE deflator for the same category, since both the alternative and the official deflators are averaged only over the subset of products for which we have new data, in contrast to the PDE deflator, which is averaged over all available PPI commodity indexes. The major contribution of the study is the estimated "drift" in the individual alternative/official price index ratios for each product, for each of the twenty-two groups of PDE, and

1. The App. A list exhibits 1967 weights for each PPI. I also have the same list from the BEA, dated 15 August 1977, with the same typed categories and 1967 weights, but with additional weights for 1958, 1963, and 1975 added in handwriting. I infer that this list of PPIs accurately reflects the sources of the PPI deflator for the period 1958–75, if not before. The list in App. A contains 161 indexes. The total of 147 cited in the text excludes the two for steel scrap and the twelve that are used only for quarterly interpolation of the three products for which outside information is available on an annual basis—aircraft, ships, and telephone equipment.

2. This new list, dated 22 February 1988, provides weights for 1986. No use of this new list is made in the present study, both because of its late arrival, and because it does not provide numerical codes for the PPIs.

for PDE as a whole. After discussing these ratios for PDE, I shall compute and discuss alternative/official price index ratios for consumer expenditures on durable goods.

If the number of products covered in this study and in the official PDE deflator is similar, what statement can be made about the number of individual price observations per product in each source? The PPI for machinery, transportation equipment, and instruments included in 1975 a total of 630 commodity indexes at the most disaggregated level, which in turn were based on a total of 1,999 price reports, for an average of 3.2 reports per index (U.S. Executive Office of the President 1977, table II-3). Some subset of these indexes is used in the PDE deflator, but it is difficult to count the size of this subset, since the PPIs included in the PDE deflator are a mixture of six-digit and eight-digit indexes at the detailed commodity level and three- or four-digit indexes that comprise groups of the detailed indexes. Roughly sixty of the indexes in the Appendix A list are at the three- or four-digit level, and the remaining eighty-seven are at the six- and eight-digit level; a rough guess is that the PDE deflator combines information from between half and two-thirds of the underlying detailed indexes in these groups, for, let us say, 1,000–1,300 price reports in 1975. In comparison, my index is based on 769 unduplicated price observations in the same year, for an average of 8.4 observations per unduplicated product index.[3] Earlier in the postwar period, coverage is smaller in both the PPI and the alternative index. There is no ready source of data on PPI coverage for machinery before 1961, although it must be based on many fewer indexes than in 1975 in view of the large number of new PPI categories introduced in 1961 and later years. In a year like 1953, my index is based on 451 unduplicated price observations, for 5.6 observations per product index. The fact that my index is based on substantially more observations per product index than the PPI is somewhat misleading, for the average number of observations per product index is inflated by the large number of yearly observations I have in just a few product categories, particularly in the hedonic price studies of automobiles and appliances. A more representative comparison is between the 3.2 reports per PPI commodity index in 1975 and the 3.3 models per product in our Sears catalog data over the full 1947–83 period.

12.2.2 Coverage by Category of PDE

Table 12.1 provides an overview of the product coverage in the twenty-two NIPA categories of PDE expenditures (these are the categories listed in NIPA

3. These figures do not include the fourteen extra products for which *CR* data have been gathered to supplement the Sears catalog indexes. The figures on observations listed in App. B refer to the number of models in the Sears catalog only. In addition are several hundred observations from *CR*. For appliances, the final results are based on the *CR* indexes, and for typewriters, outboard motors, and electric power tools on the catalog indexes. The Sears indexes for appliances and *CR* for the other products serve as a cross-check on the results.

tables 5.6 and 5.7 for nominal and real spending). Columns 1–3 list nominal expenditure shares for each of the twenty-two categories in 1947, 1967, and 1983. Here note the dramatic rise in the importance of office, computing, and accounting machinery (OCAM) on the first line and communications equipment on the second line. The most dramatic declines in shares have been experienced by transportation equipment, including trucks, buses, automobiles, and railroad equipment. Substantial declines are also observed in the shares of tractors and of agricultural, construction, and service-industry equipment. This shift in shares is of considerable importance in assessing the likely bias that might occur in the PDE deflator in years after 1983, the terminal year of this study. The categories with the greatest bias in the PDE deflator, OCAM and communications equipment, have rising nominal expenditure weights, while several categories having small errors, especially autos, tractors, and agricultural equipment, have declining nominal expenditure weights. The presumption that the rate of price increase registered by the PDE deflator after 1983 might be too low applies only with a properly constructed set of Divisia or Törnqvist weights. Any tendency for the PDE deflator to be biased upward after 1983 may be offset by the BEA's use of the implicit deflator method of calculation, which causes price increases to be understated in years after the base year for products with rapidly falling prices, like computers. Below, I shall demonstrate the extreme implications of the implicit deflator weighting system when 1972 instead of 1982 is used as a base year.

In this study, the twenty-two categories fall into two groups. The sixteen primary categories, listed without an asterisk, are those for which at least one new unduplicated source of data has been developed. The execution of the project began with the list of PPI commodity indexes for each of these sixteen categories to determine those products for which an alternative data source could be located, whether in the Sears catalog or somewhere else. Initially, the study relied heavily on unit value indexes, and then made a transition to greater reliance on Sears catalog data. The use of *CR* prices to serve as a cross-check on the Sears catalog results and as a richer source of information on quality change came relatively late in the project. Of the single-product studies for major durable goods, first came the hedonic price studies of autos, tractors, and electric generating equipment, and these were later supplemented by the new primary data and analyses of prices for aircraft, computer systems, telephone transmission and switching equipment, and railroad equipment. Listed across columns 4–9 of table 12.1 are the sources of data divided into five categories, Sears, *CR*, unit value, major product studies with explicit adjustments for energy efficiency, and major product studies without energy efficiency adjustments. The final column (9) shows the share of the weight in each category applied in the PDE deflator to PPIs for which we have no counterpart source of new information.

After all available data had been collected within the feasible time frame of the research for the sixteen primary categories, there remained the problem of what to do about the six remaining secondary categories (marked with an asterisk in table 12.1). One alternative would be to assume that the PDE deflator in those six categories is correct, another would be to apply to those six categories the average annual drift of the alternative deflators for the sixteen primary categories. In the end, the problem answered itself, because a close examination of the PPIs used by the BEA to deflate the six remaining categories revealed the use of numerous duplicate PPIs for which we have corresponding alternative product indexes. For instance, the PDE deflator for the "instruments" category is based in large part on individual PPI commodity indexes for power-driven hand tools, pumps, compressors, electrical direct measurement instruments, and metal commercial furniture, all of which are covered by the alternative data.[4] Similarly, the PDE deflator for the "other" category is based in part on individual PPI commodity indexes for lighting fixtures, metal commercial furniture, motor vehicles, and fire extinguishers. In categories where such duplicate PPIs are not used and where we have no direct evidence, plausible substitutions are made. For trucks and buses, the indexes for autos and for diesel engines are combined with equal weights (recall from chap. 11 that the main evidence supporting the unit value index for diesel engines and conflicting with the PPI came from the leading manufacturer of diesel engines for trucks). For ships and boats, I use the new indexes for products that the BEA employs for the intrayear quarterly interpolation of this category: steam and hot water equipment, pumps, compressors, electrical equipment, and nonautomotive diesel engines. This brings us to two final categories where we have no information and no obvious procedure for making substitutions: special industry machinery and mining-oilfield machinery, comprising together 7.6 percent of nominal PDE in 1967. For the former, I combine the average indexes for metalworking and service-industry machinery, and for the latter I use the index for construction machinery.

For each of the twenty-two categories, columns 4–9 show how the existing 1967 weights are allocated to the different data sources, and to products that are not covered in this study. The bottom line of the table lists the average shares of PDE allocated to the various data sources. The share of PDE that remains uncovered is 23 percent. Of the 77 percent covered share, about half is accounted for by Sears catalog indexes, and for the rest in descending order by major product energy adjusted, major product non-energy adjusted, unit

4. In the Musgrave (1986) capital stock data, the photocopy and instruments categories are combined into one category called "instruments." The NIPA publish separate data on photocopy equipment and instruments. For the photocopy category, the alternative indexes for office machinery other than electronic computers are taken and combined, using Törnqvist weights, with the instruments deflators listed in the text.

value, and *CR* indexes. The industries relying heavily on Sears catalog information are, in order of the shares listed in column 4, general industrial (e.g., pumps and compressors), metalworking, electrical, special industry, and furniture and fixtures. The *CR* indexes used here are mainly for appliances, the dominant product type in the service-industry category, and show up also in the special industry and electric n.e.c. categories. Unit value indexes provide a direct source of data for the engines and turbines and service industry categories (compressors and condensing units), and also for diesel engines in the proxy indexes for trucks, buses, and ships. Finally, the major product data sources dominate the alternative information sources for specific industries. In the energy-adjusted group (col. 7), the new index for electric utility generating equipment is used for both boilers (in the fabricated metal products category) and turbine generators (in the engines and turbines category). The auto index provides all the information for the auto category and half for trucks and buses, while the new indexes for aircraft and railroad equipment are the only source of information for those types of transportation equipment. In the non-energy-adjusted group, by far the most important are the new indexes for computer systems and for telephone transmission and switching equipment. Of much lesser importance are the alternative indexes for tractors.

12.3 The Overall Drift of the Alternative/Official Price Ratios

12.3.1 The Weighting Scheme

Thus far the alternative data have been placed into slots of the matrix displayed in table 12.1. The next step is to weight them together within each of the twenty-two categories, and then across the twenty-two categories. As stated in the introduction to this chapter, the weights should adhere to the present NIPA weights as closely as possible, so differences between the final alternative deflator and the current NIPA PDE deflator primarily reflect the new sources of data, rather than differences in weighting methods.

Within each of the twenty-two categories, the NIPA weights are followed as precisely as possible. The 1967 weights attached to each PPI ingredient of the PDE deflator are displayed in Appendix A, and the BEA has also provided the weights for the same list of PPI ingredients in 1958, 1963, 1975, and 1981. Weights for other years are interpolated linearly between these five years, and are assumed constant before 1958 and after 1981. The weights allocated by the BEA to PPIs for which we do not have alternative data series are set to zero. Details on the choice of weights from the Appendix A list are provided in the notes to the sixteen sets of tables of Appendix B, which list for each product in this study the alternative and official (usually PPI) indexes, the weight assigned for each year to each product within the PDE category, and the number of observations each year on which each "alternative" product index is based. The seventeen sets of tables in Appendix B correspond to the sixteen primary categories of PDE (those listed in table 12.1 without an asterisk) plus the "unit value industry," the aggregate of the unit value indexes developed in chapter 11. Details on the indexes and weights used for the six secondary categories are provided in Appendix C.

The alternative and official product price indexes are combined into deflators for the twenty-two categories by the Törnqvist formula, which applies the average of the current and last year's value weights to the growth rate of each price index between last year and this year. This procedure is repeated for all thirty-six sets of adjacent years, and the resulting weighted average log growth rate of the alternative and official deflators is cumulated into price indexes for each of the twenty-two categories. The resulting alternative and official indexes, as well as the alternative/official ratio, are plotted for the sixteen primary PDE categories in figures 12.1–12.16 in this chapter, and the annual data for these categories are listed as the last table in each numbered section of Appendix B. The indexes for the six secondary categories are not plotted separately, since they are based entirely on the duplication of data series already used in the sixteen primary categories. The annual time series for each of the six secondary categories is listed in the six tables of Appendix C.

12.3.2 Drift in the Alternative/Official Ratios

Table 12.2 provides a summary listing of the annual rate of drift of the alternative/official ratio for all twenty-two categories. Listed in the first

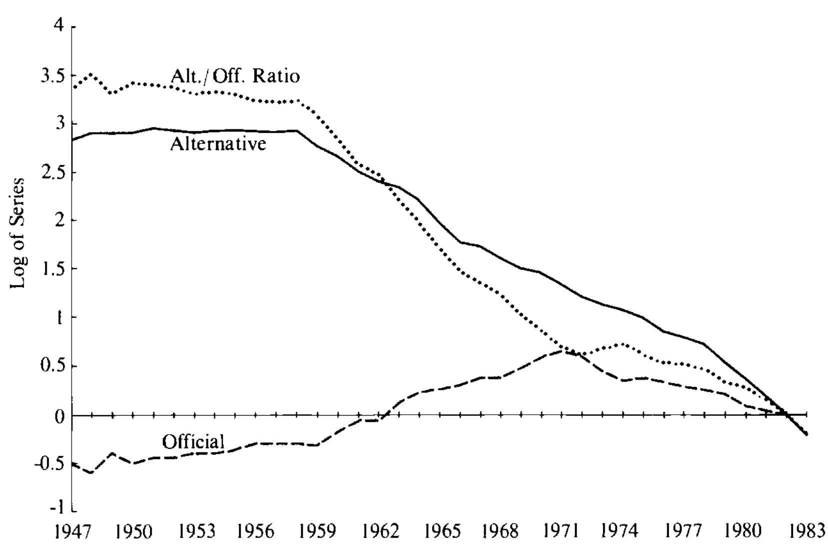

Fig. 12.1 Comparison of Törnqvist price indexes, this study and PPI, office, computing and accounting machinery, 1982 = 1.0

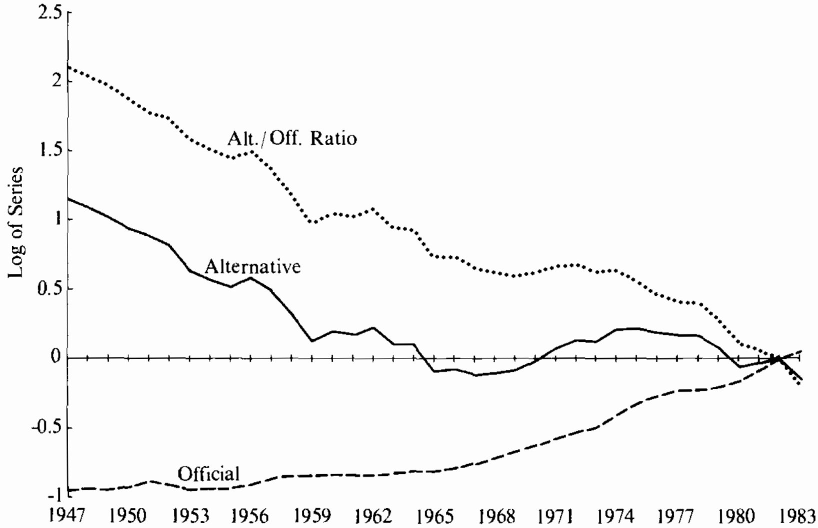

Fig. 12.2 Comparison of Törnqvist price indexes, this study and PPI, communication equipment, 1982 = 1.0

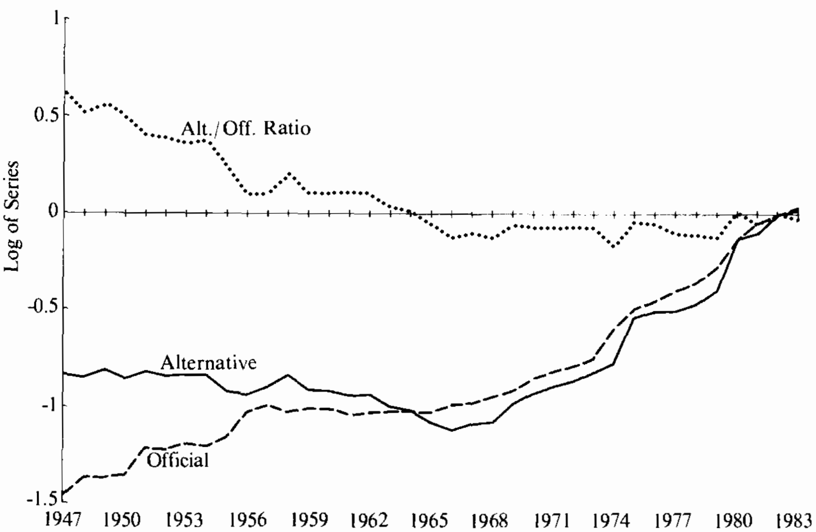

Fig. 12.3 Comparison of Törnqvist price indexes, this study and PPI, fabricated metal products, 1982 = 1.0

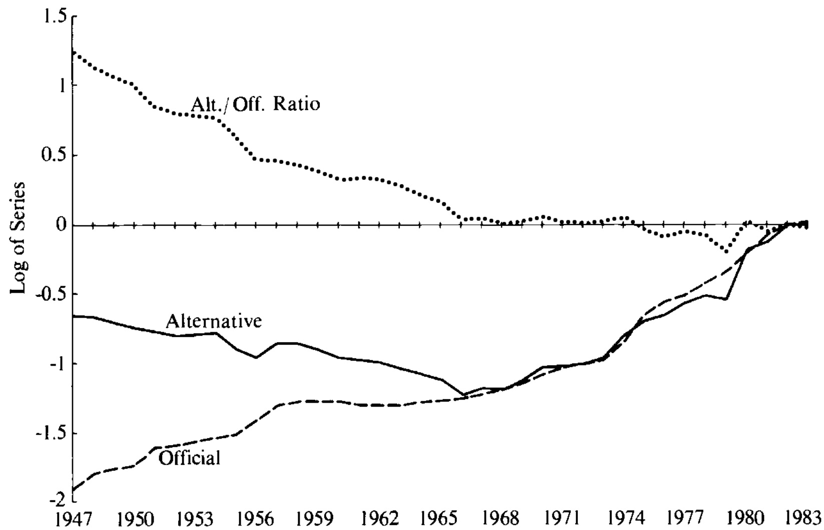

Fig. 12.4 Comparison of Törnqvist price indexes, this study and PPI, engines and turbines, 1982 = 1.0

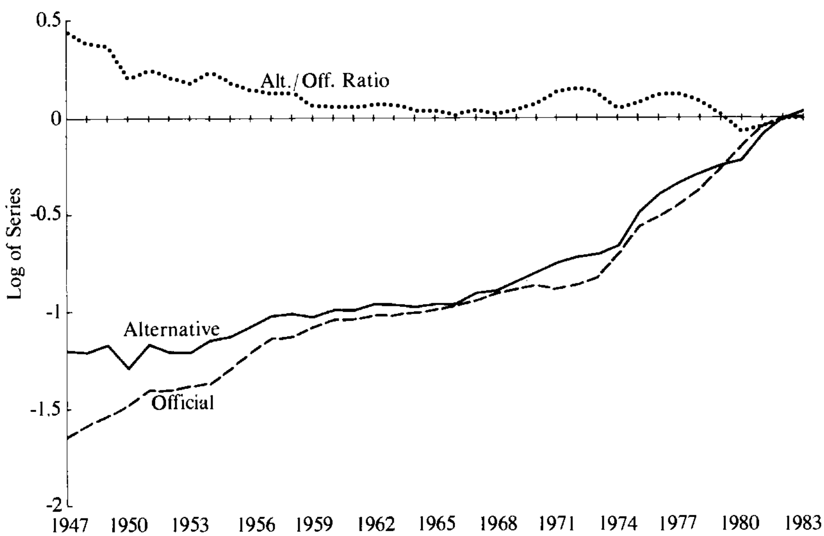

Fig. 12.5 Comparison of Törnqvist price indexes, this study and PPI, metal-working machinery, 1982 = 1.0

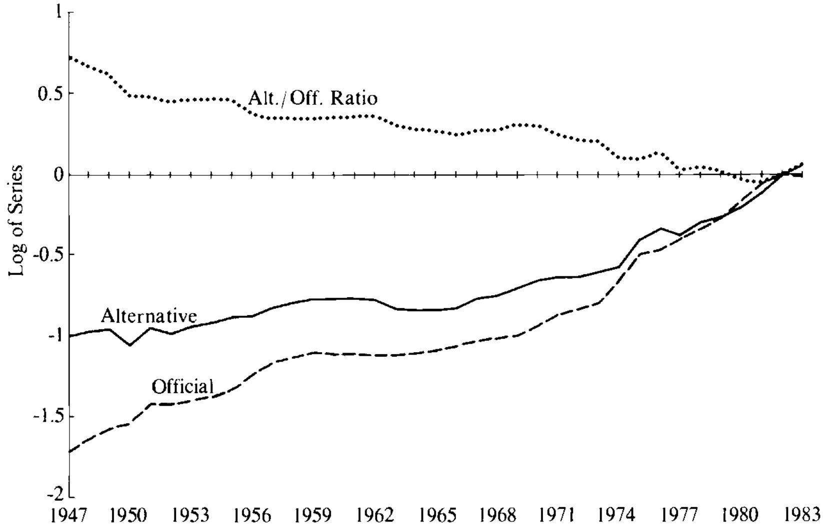

Fig. 12.6 Comparison of Törnqvist price indexes, this study and PPI, general industrial equipment, 1982 = 1.0

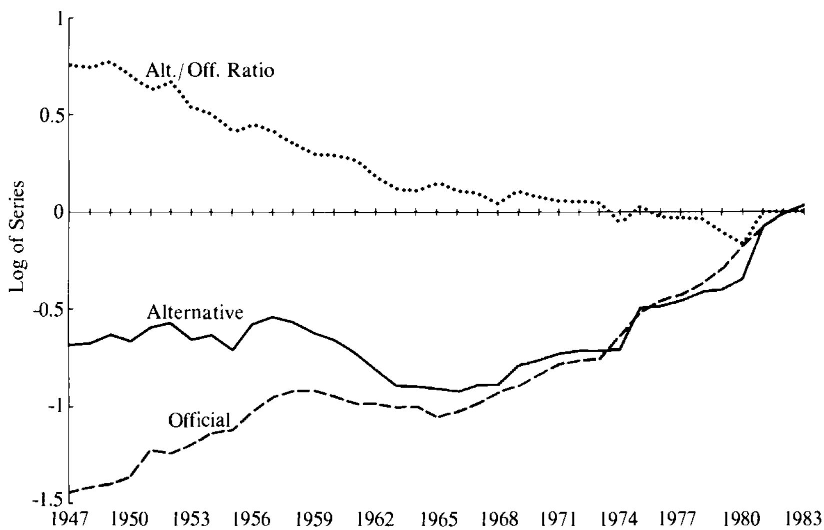

Fig. 12.7 Comparison of Törnqvist price indexes, this study and PPI, electrical transmission, distribution, and industrial apparatus, 1982 = 1.0

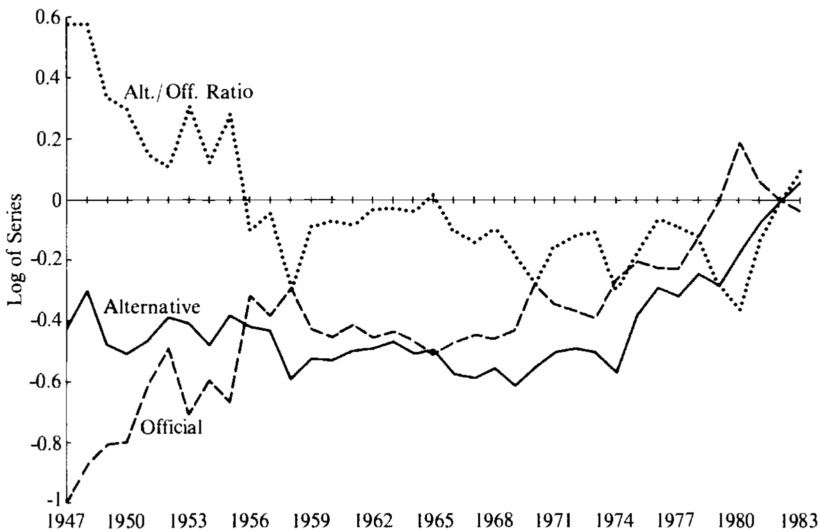

Fig. 12.8 Comparison of Törnqvist price indexes, this study and PPI, autos, 1982 = 1.0

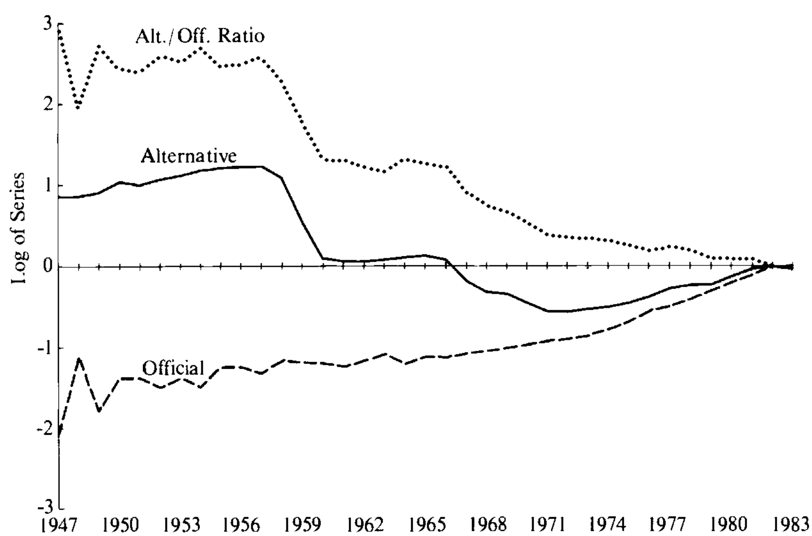

Fig. 12.9 Comparison of Törnqvist price indexes, this study and PPI, aircraft, 1982 = 1.0

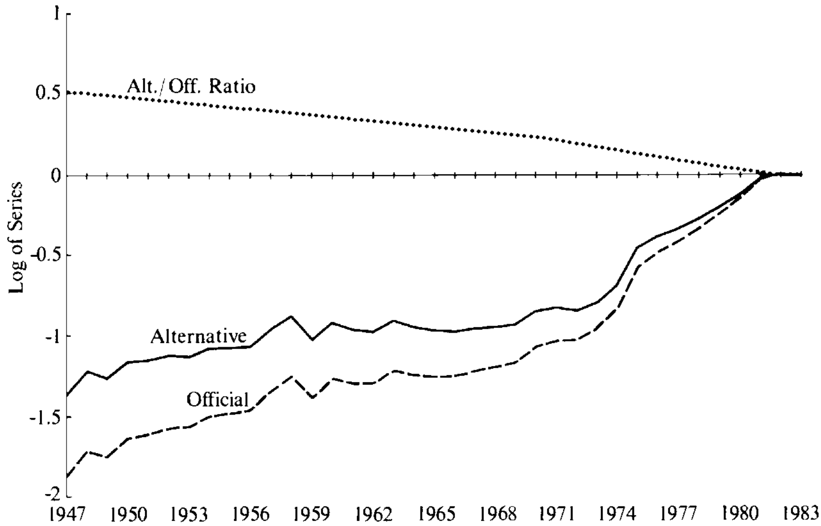

Fig. 12.10 Comparison of Törnqvist price indexes, this study and PPI, railroad equipment, 1982 = 1.0

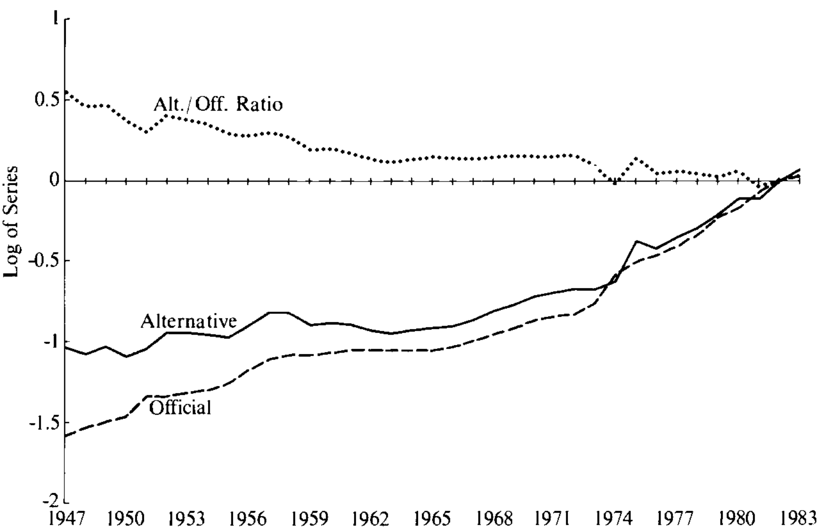

Fig. 12.11 Comparison of Törnqvist price indexes, this study and PPI, furniture and fixtures, 1982 = 1.0

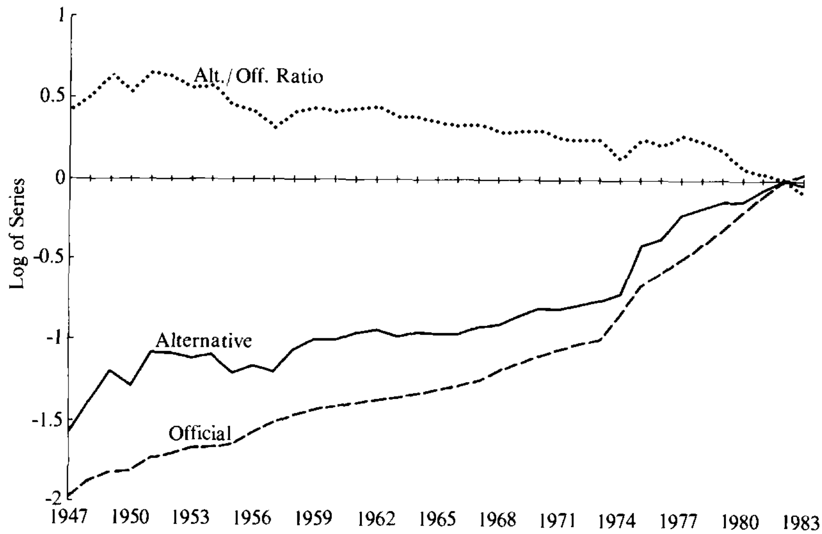

Fig. 12.12 Comparison of Törnqvist price indexes, this study and PPI, tractors, 1982 = 1.0

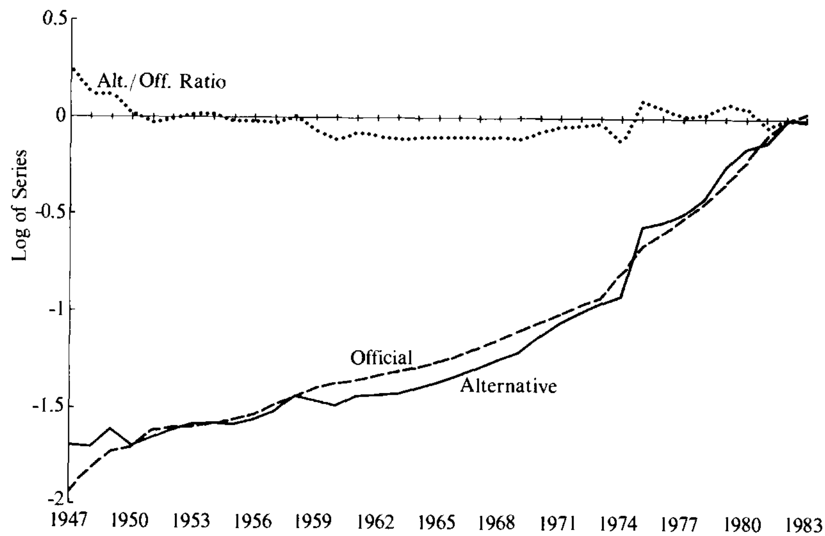

Fig. 12.13 Comparison of Törnqvist price indexes, this study and PPI, agricultural machinery, except tractors, 1982 = 1.0

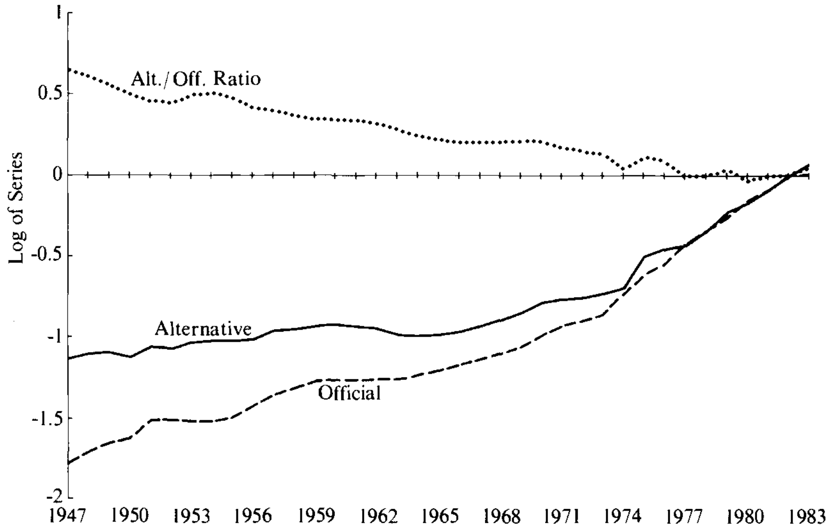

Fig. 12.14 Comparison of Törnqvist price indexes, this study and PPI, construction machinery, except tractors, 1982 = 1.0

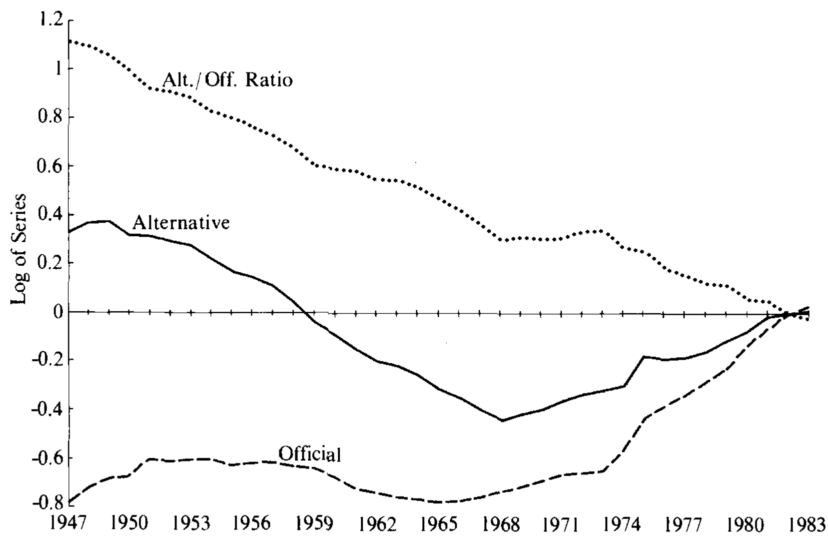

Fig. 12.15 Comparison of Törnqvist price indexes, this study and PPI, service industry machinery, 1982 = 1.0

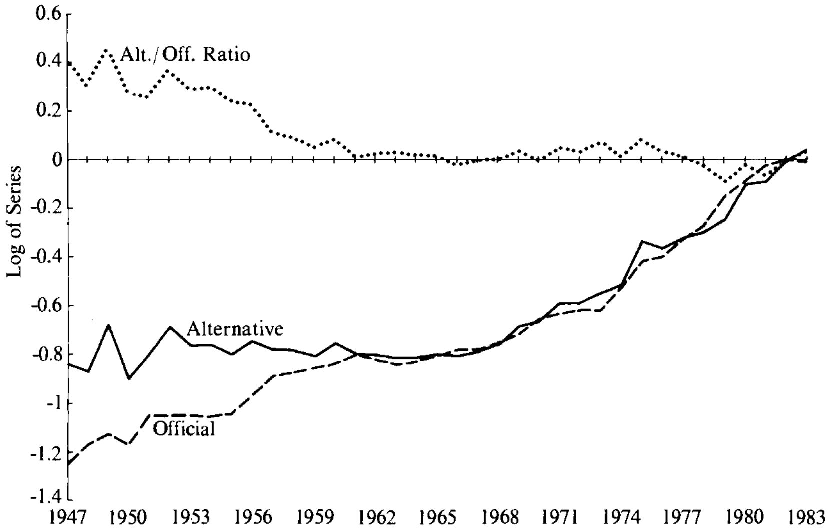

Fig. 12.16 Comparison of Törnqvist price indexes, this study and PPI, electrical equipment, N.E.C., 1982 = 1.0

column is the annual percentage rate of drift for each category over the entire period of data, usually 1947–83, and in the other columns over the three subperiods 1947–60, 1960–73, and 1973–83. At the bottom of table 12.2 is the weighted average drift, calculated by applying the Törnqvist formula to the indexes for each of the twenty-two categories, using annual NIPA nominal investment in each category as weights.

The line in the bottom section of table 12.2 labeled "Törnqvist" is really the bottom line of the whole study. For the full time period 1947–83, the Törnqvist-weighted average of the alternative price series increases at an annual rate fully 3 percent slower than the corresponding official series combined with identical weights. To appreciate the size of this number when compounded over thirty-six years, the 1947 alternative/official ratio calculated with a base year of 1983 = 1.0 is 2.94. Stated another way, the implied alternative price index in 1947 is an index number on a 1983 base almost *triple* the 1947 price index that is calculated for the official data sources with exactly the same weights (but combined with a different weighting formula, the Törnqvist). Across the postwar period, the annual rate of drift is 4.1 percent in the first subperiod, falls to 2.4 percent in the second subperiod, and then falls further to 2.1 percent in the last subperiod.

These results are based on the Törnqvist index number formula to aggregate the PDE deflator over the twenty-two categories of PDE, using NIPA weights to aggregate both the alternative and the official components of the deflator within each of the twenty-two categories. How would the results differ if we

Table 12.2 **Drift of the Ratio of Törnqvist Indexes, This Study and Corresponding PPIs, Over Selected Intervals**

	Annual Growth Rates			
NIPA Categories	Full Period of Data (1)	1947–60 (2)	1960–73 (3)	1973–83 (4)
Office, computing, and accounting machinery	−9.32	−3.94	−16.61	−6.83
Communication equipment	−5.84	−8.44	−2.89	−6.28
Instruments, photocopy and related equipment	−3.49	−3.18	−4.21	−2.97
Fabricated metal products	−1.80	−4.08	−1.28	0.49
Engines and turbines	−3.53	−7.16	−2.27	−0.44
Metalworking machinery	−1.15	−3.01	0.58	−0.96
Special industry machinery, n.e.c.	−2.48	−3.70	−1.01	−2.79
General industrial, including materials handling, equipment	−1.81	−2.87	−1.15	−1.29
Electrical transmission, distribution, and industrial apparatus	−2.11	−3.62	−1.89	−0.43
Trucks, buses, and truck trailers	−2.97	−5.74	−2.04	−0.59
Autos	−1.33	−5.02	−0.27	2.09
Aircraft	−8.29	−12.69	−7.48	−3.63
Ships and boats	−1.93	−3.17	−1.11	−1.39
Railroad equipment	−1.45	−1.24	−1.43	−1.76
Furniture and fixtures	−1.41	−2.72	−0.84	−0.46
Tractors	−1.35	−0.05	−1.28	−3.14
Agricultural machinery, except tractors	−0.70	−2.80	0.69	0.21
Construction machinery, except tractors	−1.63	−2.35	−1.63	−0.68
Mining and oilfield machinery	−1.63	−2.35	−1.63	−0.68
Service industry machinery	−3.15	−4.06	−1.91	−3.59
Electrical equipment, n.e.c.	−1.01	−2.56	−0.09	−0.20
Other	−1.99	−3.90	−0.30	−1.69
Total:				
Törnqvist	−2.96	−4.13	−2.44	−2.07
Implicit deflator, 1972 base	−2.90	−3.17	−1.88	−3.87
Implicit deflator, 1982 base	−1.97	−3.12	−1.20	−1.48

Sources: Drifts for the covered categories, App. B "group average" tables at the end of each category. For the uncovered categories, App. C. The total Törnqvist index is computed using NIPA table 5.6. The implicit deflators are computed using NIPA table 5.7.

used the NIPA weighting methodology completely, not just within the twenty-two categories, but also across categories in place of the Törnqvist formula? This would require that we calculate constant-dollar real investment in each of the twenty-two categories in 1982 prices, add up the twenty-two real investment series to form total real investment, and then calculate the implicit deflator on a 1982 base by dividing nominal PDE by this twenty-two-category real investment aggregate in 1982 dollars. To preview results that are discussed further below, the last two rows of table 12.2 display the rates of drift that are implied by the present NIPA weighting methodology, using 1972 and 1982 as alternative base years. The use of a single fixed base year, like 1972 or 1982, tends to underweight industries with declining relative prices (like computers) in years prior to the base year, and to overweight those industries in years after the base year, relative to a weighting formula like the Törnqvist that changes weights each year. This relation comes out clearly in the bottom three rows of table 2.2. While the overall 1947–83 rate of drift is similar using the Törnqvist formula or fixed 1972 weights, the latter method understates the rate of drift before 1973 and overstates it after 1973. Use of a fixed 1982 base year, as in the current NIPA, causes the rate of drift to be understated in all three periods. A subsequent graph displays the alternative and official PDE deflators that are implied by these three different sets of weights.

Having discussed differing methods of aggregation, let us now turn to the fascinating pattern of rates of drift for the twenty-two individual categories of PDE. These display a high variance both across categories and over time. Top ranked for drift is, perhaps not surprisingly, the OCAM category, where three major factors contribute to an enormous annual difference of almost 10 percent between the alternative and the official indexes. First, the BEA has no deflator for computer systems before 1969, so that the full impact of the rapid price decline for computer systems feeds straight through to the drift for OCAM during 1954–69. The rate of drift shown for OCAM in 1947–60 is much less than in 1960–73, simply because computers had a much higher weight within the OCAM category in the more recent period. Second, we have found that the PPI greatly overstates the price increase (or understates the decline) for noncomputer OCAM, particularly for adding machines, calculators, and, more recently, typewriters. Third, the BEA underweights the price change for computers before 1982 (and overweights it after 1982) by applying the implicit deflator methodology within OCAM. This practice, which was severely criticized in chapter 6, leads us to take as the "official" price index in the OCAM category not the Törnqvist-weighted average of the component price indexes but rather the actual BEA implicit deflator for OCAM (this is the only category for which the weights within the category differ from those of the BEA). While the BEA publishes a fixed-weight deflator for OCAM back to 1959, this has no bearing on the measurement of real investment in OCAM or PDE, which relies entirely on the implicit deflator.

The other two categories with extremely rapid rates of drift are communication equipment and aircraft. We saw in chapter 9 that the BEA price index for telephone transmission and switching equipment takes no account at all of the electronic revolution in telephone equipment since the early 1970s, or of the earlier advances in transmission technology. This category mirrors the rate of drift for OCAM, but at a slower rate (except during 1947–60, when computers were much less important than telephone equipment). The aircraft indexes have their greatest drift during 1947–60, mainly reflecting the enormous impact of the transition from production of piston to jet aircraft in 1958–59. The rate of drift is much lower after 1973, but still above the average Törnqvist rate of drift for all PDE.

Many other industries have much slower rates of drift. As we learned in chapter 10, the drift for the ratio of the Sears catalog indexes to the corresponding PPIs tends to be in the range of -1 to -2 percent, and fully thirteen of the twenty-two categories of table 12.2 fall into this range. When categories are ranked by the full-period rate of drift, agricultural equipment takes bottom place, reflecting the flat profile of the catalog/PPI ratio identified in chapter 10. When we count over all sixty-six cells of table 12.2 covering the twenty-two categories for the three subperiods, we find only five positive numbers, implying a more rapid price increase for the alternative than for the official deflator. The largest and doubtless the most interesting is that for automobiles during 1973–83, reflecting the spurious decline in the NIPA automobile deflator during 1980–83 that results from taking a reasonable price index for new cars to deflate new car purchases by business, but then deflating sales of used cars from the business to the household sector with a totally inconsistent deflator for used cars that greatly overstates the rate of price change. Because this used car index enters with a negative weight, it causes the PDE auto deflator to exhibit a spurious decline during 1980–83. Without this error, the rate of drift for autos during 1973–83 would be essentially zero, and the large negative drift for total PDE would be even larger.

While it is not possible to comment on every one of the cells in table 12.2, several other large negative rates of drift can be related to issues that were raised earlier in the book. The rapid annual drift of -7.16 percent for engines and turbines during 1947–60 combines the radical improvements in the efficiency of electric utility generating stations with the mysterious mismeasurement by the PPI of the price of diesel engines discussed in the detailed case study of chapter 11. By the final subperiod, the rate of drift in this category had fallen close to zero. The alternative index for service-industry machinery consists in large part of the *CR* indexes for home appliances, and the rapid rate of drift here after 1973 reflects not just the influence of improved electronics on television sets and microwave ovens, but also the explicit adjustments for improvements in energy efficiency and reliability for several types of appliances. With the exceptions of OCAM, communications equipment, and service-industry equipment, there is a fairly consistent tendency for the rate of drift in the other categories to be largest in the first subperiod, 1947–60. This would be consistent with the straightforward hypothesis that the PPI does a better job of correcting for quality change now than was true thirty-five or forty years ago.

12.3.3 Real PDE Investment by Category

The new set of alternative deflators have startling implications for real PDE investment. The bottom row of table 12.3 shows that the use of the new (''alternative'') set of deflators boosts the annual growth rate of real PDE

Table 12.3 **Average Annual Growth Rates of Real Investment, 1947–83, Applying This Study Alternative and Official Deflators NIPA Investment Series**

NIPA Categories	This Study Real Investment (1)	NIPA Real Investment (2)	Difference (3)
Office, computing, and accounting machinery	18.97	9.65	−9.32
Communication equipment	13.51	7.67	−5.84
Instruments, photocopy and related equipment	11.13	7.63	−3.50
Fabricated metal products	4.95	3.15	−1.80
Engines and turbines	4.46	0.93	−3.53
Metalworking machinery	2.83	1.69	−1.15
Special industry machinery, n.e.c.	2.94	0.46	−2.48
General industrial, including materials handling, equipment	3.50	1.69	−1.81
Electrical transmission, distribution, and industrial apparatus	5.39	3.28	−2.11
Trucks, buses, and truck trailers	5.39	2.42	−2.97
Autos	4.93	3.60	−1.33
Aircraft	15.11	6.81	−8.29
Ships and boats	0.54	−1.39	−1.93
Railroad equipment	−2.07	−3.52	−1.45
Furniture and fixtures	5.00	3.58	−1.41
Tractors	2.74	1.38	−1.35
Agricultural machinery, except tractors	1.98	1.28	−0.70
Construction machinery, except tractors	3.23	1.61	−1.63
Mining and oilfield machinery	3.29	1.66	−1.63
Service industry machinery	5.57	2.41	−3.15
Electrical equipment, n.e.c.	6.28	5.27	−1.01
Other	6.93	4.94	−1.99
Total Törnqvist Constructed PDE	6.15	3.19	2.96

Sources: Column 1: col. 2 minus col. 1 of table 12.2. Column 2: NIPA table 5.7; total PDE includes scrap. Total Törnqvist constructed PDE uses weights from NIPA table 5.6.

investment by 93 percent, from 3.19 to 6.15 percent per annum. An even more dramatic contrast occurs when we apply the magic of compound interest to these annual growth rates. The percentage increase in real PDE investment between 1947 and 1983 was 815 percent,almost four times the 215 percent registered by the NIPA.

The growth rates of investment by category display an interesting pattern. The four highest growth rates in the NIPA data in column 2 are for OCAM, communication equipment, instruments, and aircraft. These four rank in the top five in terms of the percentage rate of drift registered in column 3, which is precisely the rate of drift in column 1 of the previous table, 12.2, with the sign reversed. In the new data, all four of these categories register double-digit growth rates of real investment over the entire postwar period through 1983. Leaving aside railroad equipment, with negative growth in real investment in both the NIPA and the alternative series, the slowest growth rate of real NIPA investment is for agricultural equipment, and indeed this category has the smallest drift of the alternative/official price ratio. The appearance of a strong correlation between columns 2 and 3 is confirmed by the following simple regression equation:

$$(12.1)\quad DR_i = \underset{[1.88]}{1.10} + \underset{[3.71]}{0.48}GINIPA_i + \epsilon_i; \quad \bar{R}^2 = 0.38,\ S.E.E. = 1.79,$$

where DR is the set of category drift rates in column 3, GINIPA is the set of NIPA investment growth rates from column 2, ϵ_i is the error term, and t-ratios are in brackets. A reasonable interpretation of this correlation is that official measurement methods make the greatest errors in measuring quality change of producer durable goods in those categories that are already the most dynamic in the official data. For stagnant products like tractor-drawn plows, there is very little quality change to be missed.

12.4 Time Series for the New PDE Deflator and Associated Real PDE Investment

To convert the alternative deflator series into a new deflator for PDE, we must take into account the fact that we leave uncovered about one-quarter of the total weight in the PDE deflator. This uncovered category represents those products where PPIs are used in the PDE deflator for which we have no new source of information. The final PDE deflator is based on the assumption that the drift for the uncovered products is the same as the average drift for the covered products within each of the twenty-two PDE categories. Thus, the drift in communications equipment is not applied to metal-forming equipment, for which we have no information. Instead, I assume that the drift for metal-forming equipment is equal to the average drift for the numerous covered products in the metalworking machinery category. As shown in column 9 of table 12.1, there are no uncovered products and thus no imputations in five of the twenty-two categories: communications equipment, trucks, buses, autos, aircraft, and railroad equipment.

The difference made by coverage is shown in the difference between columns 3 and 4 of table 12.4, where the former column displays the Törnqvist-weighted average of the official price indexes for the covered products, and the latter displays the NIPA PDE deflator in the same twenty-two categories. The 1947–83 growth rate in column 3 is 3.62 percent, somewhat slower than the 4.37 percent growth rate in column 4, indicating that on average the official price indexes for the covered products register lower price increases than for the uncovered products.

The rest of table 12.4 shows the calculation of the new PDE deflator and series on real PDE investment. Nominal NIPA PDE investment in column 1 is the starting point for all the real investment series. The next three columns contrast the alternative deflator for the covered products, the official deflator for the covered products, and the NIPA PDE deflator. The ratio of the

Table 12.4 **Alternative Annual Series for the PDE Deflator and Real PDE Investment, 1947–83 (Törnqvist method, 1982 base)**

		Deflators					Real PDE (1982$)	
	NIPA Nominal PDE (billions) (1)	Alternative Törnqvist (2)	Official Törnqvist (3)	NIPA Implicit Deflator (1982 = 100) (4)	Ratio (2)/(3) (5)	This Study Implied New PDE Deflator (4)*(5) (6)	This Study (1)/(6) (Billions) (7)	NIPA (Billions) (8)
1947	15.3	78.1	27.0	20.6	2.89	59.6	25.7	74.2
1948	17.3	81.1	29.5	22.5	2.75	62.0	27.9	76.9
1949	15.7	79.7	30.9	24.0	2.58	61.9	25.4	65.5
1950	17.8	75.6	31.6	25.0	2.40	59.9	29.7	71.2
1951	19.9	79.5	35.4	26.5	2.25	59.4	33.5	75.2
1952	19.7	80.5	36.1	26.9	2.23	59.9	32.9	73.3
1953	21.5	79.3	35.3	27.7	2.25	62.2	34.6	77.7
1954	20.8	78.4	36.4	28.6	2.15	61.6	33.8	72.7
1955	23.9	78.1	36.7	29.3	2.13	62.3	38.4	81.7
1956	26.3	79.3	41.4	31.0	1.91	59.3	44.4	84.9
1957	28.6	81.2	42.8	33.3	1.90	63.2	45.2	85.9
1958	24.9	78.8	44.2	34.0	1.78	60.6	41.1	73.3
1959	28.3	75.6	43.6	34.6	1.73	60.1	47.1	81.7
1960	29.7	73.9	43.9	35.7	1.69	60.1	49.4	83.3
1961	28.9	72.6	44.2	35.9	1.64	59.0	49.0	80.5
1962	32.1	71.4	43.9	36.1	1.63	58.8	54.6	88.9
1963	34.4	69.6	44.5	36.2	1.56	56.6	60.8	95.1
1964	38.7	68.1	44.8	36.2	1.52	55.0	70.3	107.0
1965	45.8	66.2	44.7	36.4	1.48	54.0	84.9	125.8
1966	53.0	63.9	45.8	37.2	1.40	51.9	102.0	142.4
1967	53.7	64.0	47.2	38.5	1.36	52.2	102.9	139.6
1968	58.5	63.8	48.4	39.9	1.32	52.7	111.1	146.5
1969	65.2	64.6	49.9	41.6	1.29	53.8	121.1	156.8
1970	66.1	66.8	53.0	43.2	1.26	54.5	121.3	152.9
1971	68.7	67.9	54.2	45.5	1.25	57.0	120.5	151.0
1972	78.5	67.6	54.5	46.9	1.24	58.2	134.9	167.5
1973	94.5	67.9	55.0	47.3	1.23	58.4	161.7	199.6
1974	103.6	69.5	60.7	51.1	1.14	58.5	177.1	202.7
1975	106.6	80.2	67.7	59.8	1.19	70.8	150.5	178.4
1976	119.9	81.5	70.1	64.4	1.16	74.9	160.1	186.2
1977	147.4	82.5	72.8	68.3	1.13	77.5	190.1	215.7
1978	178.0	86.1	77.6	73.3	1.11	81.3	218.9	242.8
1979	203.3	86.8	83.6	78.6	1.04	81.6	249.1	258.8
1980	208.9	90.6	91.3	86.0	0.99	85.3	244.8	243.0
1981	230.7	95.7	96.3	93.6	0.99	93.0	248.0	246.4
1982	223.4	100.0	100.0	100.0	1.00	100.0	223.4	223.4
1983	232.8	99.1	99.4	99.5	1.00	99.1	234.8	233.9

Sources: NIPA nominal and real PDE include scrap. Column 1: NIPA table 5.6. Columns 2 and 3: this study. Column 4: NIPA tables 5.6 and 5.7. Column 8: NIPA table 5.7.

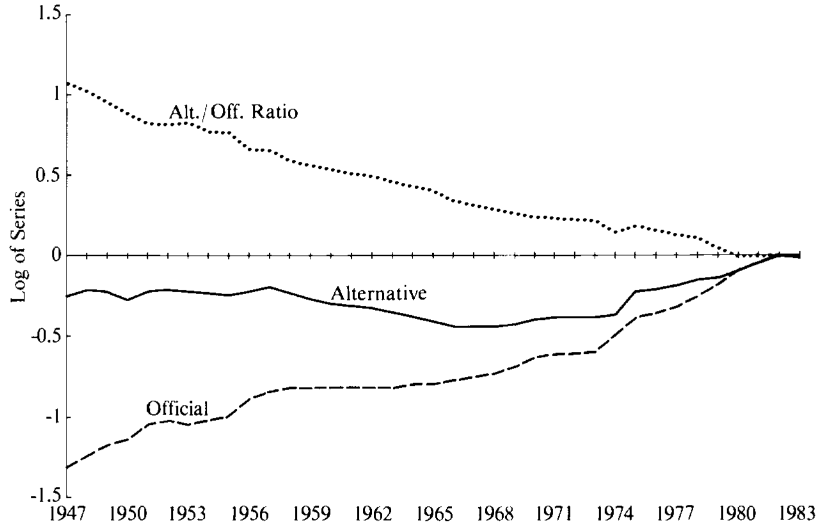

Fig. 12.17 Comparison of Törnqvist price indexes, this study and PPI, 22 categories, 1982 = 1.0

alternative and official deflators in columns 2 and 3 is displayed in column 5, and this ratio with its components is plotted in figure 12.17. There we see the smooth downward movement of the alternative series between 1957 and 1966, followed by a plateau and then inflation during 1975–82. The alternative/official ratio has the zigzag in 1974–75 that we have already identified as the delayed reaction of the Sears catalog prices to the end of price controls, and the ratio also has a sharp plunge in 1956 that is not evident in the Sears catalog index developed in chapter 10.

Returning to table 12.4, the final step is to calculate a new PDE deflator by applying the alternative/official ratio in each of the twenty-two categories to the NIPA PDE deflator in that category, thus imputing to the uncovered items the drift in the covered items within the same category. The resulting new PDE deflator in column 6 rises faster than the alternative deflator in column 2 as the result of the faster inflation already measured by the NIPA for the uncovered items. Finally, the two right-hand columns of table 12.4 list the implied real PDE investment series. That based on the new deflator developed in this study (col. 7) increases at 6.15 percent per annum over 1947–83, as contrasted with 3.19 percent in the official NIPA real PDE investment series. These growth rates are precisely the same as those appearing in the bottom row of table 12.3.

12.4.1 The Folly of the Implicit Deflator Method

Section 6.7.1 discussed the translation of computer prices into a deflator for the OCAM category and noted the defects for this purpose of the implicit deflator methodology, currently used throughout the NIPA to calculate real investment. There are four central flaws of the implicit deflator method. First, by applying the structure of relative prices in the base year to all other years, the method understates the importance of real spending in categories with rapidly falling prices in every year prior to the base year and overstates their importance after the base year. The reverse is true for components with rapidly rising prices. Second, the method relates the prices of each year separately to the base year, so that price changes calculated between adjacent nonbase years are invalid. A bizarre example occurs in the implicit OCAM deflator in the current NIPA, which rises rapidly from 1957 to 1972 even though both its computer and its noncomputer components are declining over this period. Third, the effect of relatively recent products is ignored in long historical comparisons, as in the case of computers; the change in the OCAM deflator between 1957 and 1982 is identical to that of noncomputer products, as if computers had never existed during that interval. Finally, an implication of the first flaw is the fourth, that the growth rate of prices and the resulting real investment series is totally dependent on which year is chosen as the base year. To reflect this sensitivity to the choice of base year, the bottom section of table 12.2 displays the difference in the rates of drift of the alternative and official price indexes made when the implicit deflator methodology is applied with 1972 and 1982 as alternative base years.

Since economists studying long-run growth issues have been using Törnqvist and the related Divisia-type indexes for several decades, at least since the work of Solow (1957) and Jorgenson and Griliches (1967), it is surprising that the U.S. national accounts should be based on such a deficient method of aggregation. The reason that the implicit deflator method has lasted so long is doubtless that, prior to the introduction of a price index for computers, the anomalies introduced by the implicit deflator method were not very important in practice. However, in this study, which yields such widely divergent deflator growth rates for the individual categories of PDE, the use of the Törnqvist approximation to the ideal index number is essential. In this section, I pause briefly to demonstrate the misleading results that would have been obtained if the new numbers had been combined with the implicit deflator method.

Recall that the implicit deflator overstates the importance of components with declining prices in every year after the base year. This phenomenon can be dramatized by choosing 1972 as a base year and recalculating the alternative and official price indexes for the twenty-two categories without the coverage adjustment. The time series for the alternative and official PDE deflators are displayed in figure 12.17 for the Törnqvist method, figure 12.18 for the implicit deflator method with 1972 weights, and figure 12.19 for the implicit deflator method with 1982 weights. In figure 12.18, we see that the alternative deflator would actually have declined from 1972 to 1983 with the implicit deflator method using a 1972 base year, despite the fact that prices in

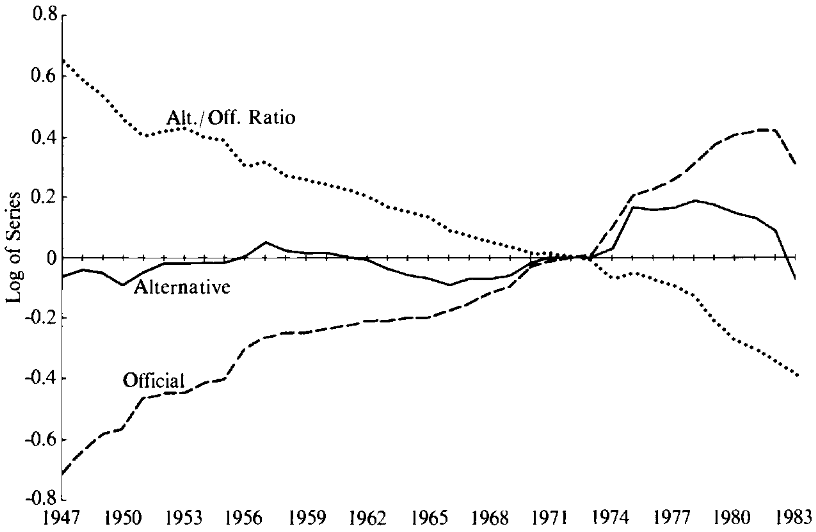

Fig. 12.18 Comparison of implicit price indexes, this study and PPI, 22 categories, 1972 = 1.0

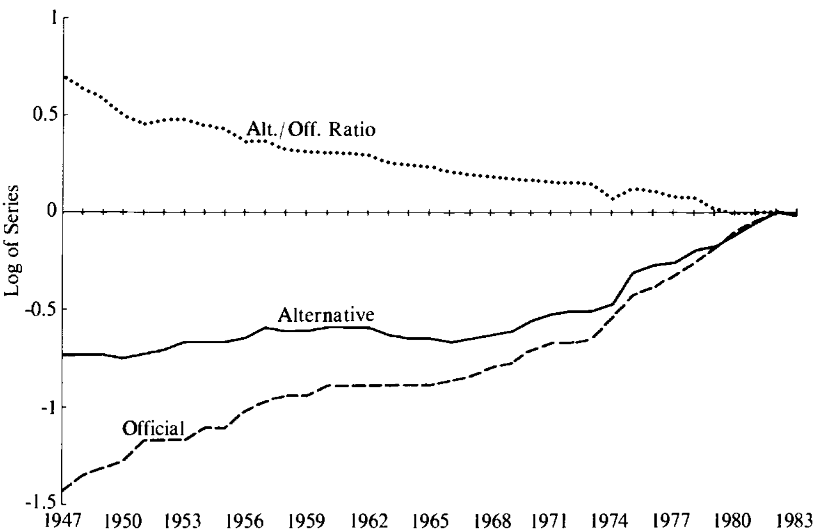

Fig. 12.19 Comparison of implicit price indexes, this study and PPI, 22 categories, 1982 = 1.0

twenty of the twenty-two categories increased over this period, most of them more than doubling. The 1972–83 increase in the implicit deflator would have been only 37 percent even with official price data. Figure 12.19 repeats the same calculation in precisely the same way but switches the base year from 1972 to 1982. With the alternative data, the implicit deflator grows from 1972 to 1983 by 63 percent instead of declining by 7 percent. With the official data, the implicit deflator grows by 94 percent instead of by 37 percent.

Clearly, any implications of this study that the PDE deflator overstates the rate of price increase become increasingly inappropriate the further the present method is extended after the current 1982 base year. Using the 1982 base year, the new PDE deflator shows much less inflation than the official series, whether the Törnqvist or implicit deflator method is used through the end of the study in 1983. For years after 1983, there is no implication that the growth in the PDE deflator is biased upward, and in fact it may be biased downward by an increasingly large amount the further time extends beyond 1982.

12.5 Investment/GNP and Capital Stock/GNP Ratios

One of the longstanding stylized facts about the U.S. economy is the stability of the investment/GNP ratio. As shown in table 12.5, column 4, the NIPA ratio of structures and equipment investment to real GNP was almost identical in 1947 and 1983, with ratios of 11.4 and 11.1 percent, respectively. One of the most important implications of this study is that this stylized fact has been far from the truth for the entire postwar era. The first two columns in table 12.5 contrast the official and the new ratios of PDE investment to GNP. The NIPA ratio remains constant, while the new ratio *triples*. Even though this study does not contain any new results on structures prices or real investment, the ratio of structures plus PDE investment to real GNP doubles when the new data are substituted for the official data.

Even with the Törnqvist method of aggregation, the absolute level of the investment/GNP ratio is sensitive to the choice of base year. With 1982 as a base, as in table 12.5, the investment/GNP ratio is very small in 1947. With 1929 as a base year, the investment/GNP ratio in 1983 would be huge. There is no escape from this inevitable arithmetic as long as we replace the stylized fact of equal growth rates of investment and GNP by the new fact that investment has been growing much faster than GNP. On any arbitrary base year, the investment/GNP ratio will be huge in a distant future year and tiny in a far distant past year.

Because the new data on the investment/GNP ratios overturn standard impressions of the process of economic growth, they raise new issues that will need to be discussed. First among these is the most obvious from a longer historical perspective. If the investment/GNP ratio doubled between 1947–83, what happened in the 100 years prior to that? Is the large quality bias in official price indexes for capital goods a new problem or an age-old problem?

Table 12.5 **Real Investment as a Percentage of GNP, NIPA, and This Study, in Constant 1982 Prices**

	Equipment			Total	
	NIPA (1)	This Study (2)	Structures, NIPA (3)	NIPA (4)	This Study (5)
1947	6.96	2.58	4.45	11.41	6.22
1948	6.94	2.70	4.55	11.49	6.45
1949	5.91	2.44	4.45	10.35	5.97
1950	5.92	2.62	4.39	10.30	6.22
1951	5.66	2.66	4.25	9.92	6.19
1952	5.31	2.51	4.15	9.46	5.91
1953	5.41	2.53	4.34	9.75	6.05
1954	5.13	2.50	4.58	9.72	6.13
1955	5.47	2.70	4.64	10.11	6.46
1956	5.56	3.05	4.95	10.51	7.12
1957	5.54	3.05	4.85	10.39	7.05
1958	4.76	2.77	4.59	9.35	6.50
1959	5.02	3.00	4.41	9.43	6.70
1960	5.00	3.07	4.57	9.57	6.89
1961	4.71	2.96	4.55	9.26	6.71
1962	4.94	3.13	4.52	9.46	6.93
1963	5.08	3.35	4.36	9.43	7.11
1964	5.42	3.67	4.45	9.88	7.60
1965	6.03	4.19	4.88	10.90	8.55
1966	6.45	4.75	4.89	11.34	9.24
1967	6.15	4.64	4.64	10.79	8.93
1968	6.19	4.80	4.57	10.76	9.07
1969	6.47	5.10	4.66	11.13	9.49
1970	6.33	5.12	4.60	10.93	9.47
1971	6.08	4.94	4.32	10.40	9.04
1972	6.42	5.28	4.20	10.62	9.33
1973	7.27	6.02	4.29	11.56	10.24
1974	7.43	6.60	4.22	11.65	10.78
1975	6.62	5.69	3.81	10.43	9.45
1976	6.59	5.76	3.69	10.28	9.41
1977	7.29	6.51	3.66	10.95	10.20
1978	7.79	7.11	3.83	11.62	10.99
1979	8.11	7.83	4.09	12.20	11.95
1980	7.62	7.69	4.27	11.90	11.96
1981	7.58	7.64	4.58	12.16	12.22
1982	7.06	7.06	4.53	11.58	11.58
1983	7.14	7.16	3.96	11.09	11.12

Sources: GNP for cols. 1, 3, and 4 is NIPA. GNP for cols. 2 and 5 is NIPA with the new PDE and new consumer durables substituted in by straight addition, not by Törnqvist. The numerator of col. 4 is NIPA table 5.7, row 2. The numerator of col. 5 is a Törnqvist of cols. 2 and 3.

More important for the near future, how long will investment continue to grow faster than GNP? Will the rapid growth rate of real equipment investment eventually lift the U.S. economy out of the productivity doldrums? Answers to these questions will require substantial further research, using the results of this book as a point of departure.

12.5.1 Constructing a New Times Series on the Capital Stock

The official BEA data on the fixed reproducible capital stock are constructed by a complex methodology involving the application of Winfrey decay distributions to each disaggregated category of investment. In this study, a shortcut method is used to calculate a new capital stock of PDE for the period 1947–83. Because we have no evidence covering the period before 1947, the new real investment series for 1947–83 must be linked to Musgrave's (1986) official series on flows of real equipment investment prior to 1947. Lacking the detailed Winfrey distributions for each PDE category, I assume a one-hoss shay distribution and estimate the service lifetime implicit in the Musgrave capital stock data. This involves searching through iteration for the implicit service lifetime for a particular category of PDE, which in a particular year is the number of years that investment must remain in the capital stock in order to obtain Musgrave's capital stock for that category of PDE. This approach allows us to calculate the implications of replacing NIPA investment for each category with the alternative series, holding constant the implicit service lifetime of capital in that category for each capital stock series, both that which we construct from the official deflators and the alternative capital stock series which we construct from the new alternative deflators.

The BEA and alternative capital stocks for equipment are shown in columns 1 and 2 of table 12.6 and are combined with the existing BEA series on the capital stock of nonresidential structures in columns 4 and 5. The stocks of equipment and structures are aggregated by the Törnqvist formula, using as weights the nominal gross flow of services, as explained in the notes to table 12.6. Table 12.7 summarizes the annual growth rates of the capital stock over key intervals for equipment using the official and alternative deflators, for the official structures series, and for the aggregate of equipment and structures.

The alternative and official NIPA capital stock growth rates for equipment, that is, PDE, differ by about 3 percent per annum in table 12.7, about the same amount as the difference between the annual growth rates of the alternative and official equipment investment series displayed above in tables 12.3 and 12.4. For the subintervals, the differences in the growth rates of the equipment capital stock are, respectively, 3.06, 3.25, and 2.63 percent per annum. The growth rate of the equipment capital stock differs most, then, in the middle interval (1960–73), in contrast to the growth rate of equipment investment, which differs most in the first period (1947–60). This difference in timing reflects the fact that this study starts only in 1947 and has little effect on the growth rate of the capital stock in the first few years after 1947, when the majority of equipment capital consisted of items purchased before 1947.

Table 12.6 **Real Capital Stocks, BEA Wealth Data Base and This Study, Billions 1982 Dollars, and Real Capital Input Index, 1982 = 100**

	Equipment			Capital Input Index	
	This Study (1)	BEA (2)	Structures, BEA (3)	This Study (4)	BEA (5)
1947	190.	548.	1,292.	16.5	29.0
1948	210.	593.	1,302.	17.2	30.0
1949	227.	628.	1,311.	17.9	30.9
1950	250.	669.	1,324.	18.7	31.9
1951	276.	713.	1,340.	19.7	33.1
1952	301.	755.	1,357.	20.6	34.2
1953	327.	799.	1,378.	21.7	35.4
1954	352.	836.	1,401.	22.7	36.5
1955	381.	877.	1,429.	23.8	37.8
1956	413.	919.	1,463.	25.1	39.2
1957	446.	959.	1,496.	26.4	40.5
1958	471.	982.	1,524.	27.4	41.3
1959	503.	1,011.	1,554.	28.7	42.4
1960	536.	1,039.	1,589.	30.0	43.4
1961	568.	1,063.	1,626.	31.3	44.4
1962	605.	1,093.	1,664.	32.8	45.6
1963	647.	1,128.	1,704.	34.4	46.9
1964	695.	1,173.	1,750.	36.2	48.5
1965	756.	1,234.	1,808.	38.6	50.6
1966	833.	1,308.	1,869.	41.4	53.1
1967	908.	1,379.	1,928.	44.1	55.5
1968	992.	1,456.	1,989.	47.0	58.0
1969	1,085.	1,541.	2,055.	50.2	60.8
1970	1,175.	1,620.	2,118.	53.3	63.4
1971	1,263.	1,693.	2,178.	56.2	65.8
1972	1,365.	1,779.	2,237.	59.4	68.5
1973	1,490.	1,892.	2,305.	63.2	71.8
1974	1,625.	2,005.	2,373.	67.2	75.1
1975	1,725.	2,084.	2,429.	70.1	77.5
1976	1,832.	2,166.	2,483.	73.1	79.9
1977	1,968.	2,273.	2,541.	76.8	82.9
1978	2,131.	2,400.	2,609.	81.1	86.4
1979	2,325.	2,539.	2,686.	86.1	90.2
1980	2,510.	2,652.	2,769.	91.0	93.7
1981	2,693.	2,759.	2,865.	96.0	97.2
1982	2,834.	2,834.	2,951.	100.0	100.0
1983	2,986.	2,913.	3,017.	103.9	102.5

Sources: BEA wealth data base, Musgrave (1986). See text for the calculation of col. 1.

The capital input index (col. 4) is obtained by a Törnqvist algorithm weighting the new equipment stock growth rate with the BEA structures stock growth rate. The weights are the respective shares in the gross nominal flow of services, as follows:

$$w_E = [0.15 \times (\text{gross nominal equipment stock})]/[0.15 \times (\text{gross nominal equipment stock}) + 0.08 \times (\text{gross nominal structures stock})],\ w_s = 1 - w_E .$$

The same algorithm is applied to obtain col. 5. 0.15 is the sum of the rate of return, 0.05, and the depreciation rate for equipment, 0.10. 0.08 is the sum of the rate of return, 0.05, and the depreciation rate for structures, 0.03.

Table 12.7 Average Annual Growth Rates of Alternative and Official Series for Real Investment, Selected Intervals, 1947–83

Capital Stock Concept	1947–83	1947–60	1960–73	1973–83
NIPA PDE	4.64	4.92	4.61	4.32
Alternative PDE	7.65	7.98	7.86	6.95
NIPA structures	2.36	1.59	2.86	2.69
NIPA total	3.25	2.74	3.60	3.45
Alternative total	4.31	3.66	4.96	4.31

Effects of the new price data on the growth of the capital stock of equipment and structures together are much smaller than for equipment alone, as would be expected in view of the facts that no alternative deflators for structures have been created in this study, and that structures represent well over half the total capital stock. Despite the absence of new evidence on structures, however, this study does have major implications for the behavior of the aggregate capital-output ratio. Table 12.8 exhibits ratios of capital to real GNP in 1982 prices for equipment, structures, and the total of equipment plus structures, using both the alternative equipment deflator and the official NIPA equipment deflators.[5] All columns of table 12.8 define the denominator of the capital/output ratio to be real GNP using the appropriate set of deflators for consumer and producer durables; that is, the real GNP is based on the alternative deflators for durables when compared with the capital stock based on the alternative deflators, whereas the official real GNP measure is compared with the capital stock based on the official deflators for expenditures on durables goods.

In the official data, the capital/output ratio is almost the same in 1947 and 1983, after displaying a substantial decline during 1947–67 and an increase during 1967–83. The capital-output ratio implied by this study is quite different. The increase in the capital-output ratio for equipment between 1947 and 1983 is 406 percent, compared to a much smaller 75 percent in the official data. For the aggregate of structures and equipment, the 1947–83 increase in the capital-output ratio is 44 percent, as contrasted to only 5 percent in the official data.

12.6 Alternative Deflators for Expenditures on Consumer Durable Goods

Although the primary emphasis of this study has been on price indexes for PDE, several of the price indexes can be used in compiling an alternative deflator for consumer durables. No new data have been collected for the

5. The official data in tables 12.6 and 12.7 are labeled "BEA" rather than "NIPA," because they are not part of the national income accounts, but rather are created as part of the ongoing BEA capital stock study.

Table 12.8 **Real Gross Capital Stocks/Real GNP Ratios, BEA and This Study, in Constant 1982 Prices**

	Equipment			Total	
	BEA (1)	This Study (2)	Structures, BEA (3)	BEA (4)	This Study (5)
1947	0.51	0.19	1.21	1.72	1.27
1948	0.54	0.20	1.17	1.71	1.27
1949	0.57	0.22	1.18	1.75	1.29
1950	0.56	0.22	1.10	1.66	1.23
1951	0.54	0.22	1.01	1.55	1.15
1952	0.55	0.23	0.98	1.53	1.14
1953	0.56	0.24	0.96	1.52	1.14
1954	0.59	0.26	0.99	1.58	1.20
1955	0.59	0.27	0.96	1.54	1.18
1956	0.60	0.28	0.96	1.56	1.21
1957	0.62	0.30	0.96	1.58	1.24
1958	0.64	0.32	0.99	1.63	1.28
1959	0.62	0.32	0.95	1.57	1.25
1960	0.62	0.33	0.95	1.58	1.27
1961	0.62	0.34	0.95	1.57	1.28
1962	0.61	0.35	0.92	1.53	1.26
1963	0.60	0.36	0.91	1.51	1.26
1964	0.59	0.36	0.89	1.48	1.25
1965	0.59	0.37	0.87	1.46	1.25
1966	0.59	0.39	0.85	1.44	1.25
1967	0.61	0.41	0.85	1.46	1.29
1968	0.62	0.43	0.84	1.46	1.30
1969	0.64	0.46	0.85	1.48	1.34
1970	0.67	0.50	0.88	1.55	1.42
1971	0.68	0.52	0.88	1.56	1.44
1972	0.68	0.53	0.86	1.54	1.44
1973	0.69	0.56	0.84	1.53	1.45
1974	0.73	0.61	0.87	1.60	1.53
1975	0.77	0.65	0.90	1.67	1.61
1976	0.77	0.66	0.88	1.64	1.58
1977	0.77	0.67	0.86	1.63	1.57
1978	0.77	0.69	0.84	1.61	1.56
1979	0.80	0.73	0.84	1.64	1.59
1980	0.83	0.79	0.87	1.70	1.67
1981	0.85	0.83	0.88	1.73	1.72
1982	0.90	0.90	0.93	1.83	1.83
1983	0.89	0.91	0.92	1.81	1.83

Sources: See the notes to table 12.5 for the GNP concept used in each column. The numerator of col. 2 is constructed, first by accumulation at the level of each category of the real investments of the BEA wealth data base (Musgrave 1986), using implicit service lives as described in the text, then by aggregation using a Törnqvist with weights being the gross nominal capital stocks. The numerators of cols. 4 and 5 are Törnqvist of equipment stock and structures stock, respectively, BEA and this study. The weights are calculated from the gross nominal capital stocks.

explicit purpose of developing a consumer durables deflator, although copious price data are available in the Sears catalog and in *CR* that could be used in a future study to provide more complete coverage of consumer durables. Here, the findings for consumer durables are based solely on the subset of the PDE price data that already refer to consumer durables, and that were

Table 12.9 **Relative Importance of Covered and Uncovered Categories of Consumer Durables in 1982**

	$ Billions in 1982	Percent
Covered categories:	130.7	51.8
New autos	53.3	21.1
Net purchases of used autos	19.6	7.8
Other motor vehicles	15.6	6.2
Kitchen and other household appliances	17.7	7.0
Radio and television receivers	24.5	9.7
Noncovered categories:	121.8	48.1
Tires, tubes, accessories, and other parts	20.2	8.0
Furniture, including mattresses and bedsprings	21.6	8.5
China, glassware, tableware, and utensils	10.4	4.1
Other durable house furnishings	21.5	8.5
Other	48.1	19.0
Total consumer durables	252.7	99.9

collected to match those components of the official PDE deflator that in fact refer to durable goods purchased by consumers as well as by business firms, including those for automobiles, kitchen and other household appliances, radios, and television sets. Existing official deflators for all other categories of consumer durables are assumed to be correct. Table 12.9 indicates the extent of the covered and noncovered categories of consumer durable expenditures in 1982. As shown in table 12.9, the fraction of 1982 consumer durable expenditures representing goods with new price indexes developed in this study stands at a bit more than half. Because the official NIPA deflators for the other half are assumed to be correct, at least for the purposes of the present computation, it is not surprising to find that the overall annual rate of drift of the alternative deflator relative to the official deflator is much smaller than for PDE.

The alternative price indexes are taken from the detailed product tables in Appendix B. Unlike the alternative PDE deflator discussed earlier in this chapter, which is compiled from NIPA weights within the twenty-two categories of PDE and then aggregated using the Törnqvist formula across the twenty-two categories, here for consumer durables all the component price indexes are aggregated using the Törnqvist method. The required nominal value weights are the retail value of sales of each product, including automobiles, each type of appliance, radio, and television. Details are given in the notes to table 12.10, and the body of that table displays the results. The bottom row exhibits the overall rate of drift for the consumer durables deflator, −1.54 percent per annum over the full 1947–83 period, and respective rates of −2.21, −1.24, and −1.05 percent per year over the three subintervals. In all three of the major subcategories for which we have new information, motor vehicles, appliances, and radio-television, the rate of drift

Table 12.10 Drift of the Ratio of Törnqvist Indexes, This Study and Corresponding NIPA Implicit Deflators for Selected Consumer Durables, 1982 Base—Over Selected Intervals

	Annual Growth Rates			
NIPA Categories	Full Period of Data (1)	1947–60 (2)	1960–73 (3)	1973–83 (4)
1. Motor vehicles and parts	−1.71	−2.39	−1.69	−0.85
2. Furniture and household equipment	−1.79	−2.52	−1.26	−1.55
2.1 Kitchen and other household appliances	−3.22	−4.39	−2.37	−2.83
2.2 Radios and TVs	−5.94	−9.07	−3.77	−4.69
3. Total consumer durables	−1.54	−2.21	−1.24	−1.05

Sources by row: (**1**) The official index is the implicit deflator for the combined categories of new autos, net purchases of used autos, and other motor vehicles, listed in rows 4, 5, and 6 in table 2.5 of the NIPA. The corresponding alternative index is taken from App. B.8, autos. The alternative and official indexes for the category of tires, tubes, accessories, and other parts are taken to be the implicit deflator for this category. The indexes for the overall category of motor vehicles and parts are Törnqvist indexes of the above two, respectively for the alternative and the official, using weights provided by the corresponding nominal series of NIPA table 2.4. (**2**) Furniture and household equipment results from a Törnqvist of 2.1, 2.2, and the implicit deflator of the categories listed as rows 9, 11, and 13 of NIPA table 2.5. The weights are from NIPA table 2.4. (**2.1**) The official index is the implicit deflator from the NIPA for this category. The alternative is a Törnqvist of price indexes for automatic washing machines, clothes dryers, refrigerators, microwave ovens, vacuum cleaners, automatic coffee makers, room air conditioners, and propeller fans as they appear in App. B. The weights are from retail value tables of the *Statistical Abstract of the United States*, various issues, in the listing for home appliances. I used data for 1950, 1955, 1960, 1965, 1970, 1975, 1979, 1981, and 1983, and interpolated to construct complete series of weights. (**2.2**) The official index is the NIPA implicit deflator for radios, TVs, records, and musical instruments. The alternative is a Törnqvist of the alternative indexes for radios and for TVs listed in App. B, table B.2. Weights are from the *Statistical Abstract of the United States*. (**3**) Row 3 is a Törnqvist of rows 1, 2, and the implicit deflator for the category other, row 14 of NIPA table 2.5.

Note: NIPA implicit deflators at the level of disaggregation considered include additional items not covered by the alternative indexes of this study. For instance, the alternative index for kitchen and other household appliances does not cover cooking ranges.

is more rapid before 1960 than afterward. For motor vehicles, the rate of drift decelerates further after 1973, while for appliances and radio-television, the rate of drift accelerates in the 1973–83 subinterval as compared to the middle 1960–73 interval. The rate of drift for consumer durables as a whole is quite close to the rate of drift for motor vehicles. The much faster rates of drift for appliances and, particularly, for radio-television are canceled out by the fact that the existing NIPA deflators for fully half of consumer durable expenditures are assumed to be correct.[6]

Table 12.11 converts the alternative deflator for consumer durable spending into a new series for real expenditures on consumer durables. The table is laid

6. The reader will note that there is a negative drift for motor vehicles in table 12.8 for consumer durables in the last subinterval, 1973–83, in contrast to the positive drift of 2.09 percent per annum shown for the PDE auto category in table 12.2 above. This discrepancy reflects entirely the role of the CPI index for used cars, which rises at a spuriously rapid rate due to the absence of quality adjustments, together with the fact that expenditures on used cars enter PDE with a negative weight but consumer durable expenditures with a positive weight.

Table 12.11 **Annual Series for the Consumer Durables Deflator and Real Consumer Durables Expenditures, This Study and NIPA, 1947–83 (Törnqvist method)**

	NIPA Nominal Consumer Durables (billions) (1)	Indexes: Alternative Törnqvist (2)	Indexes: Official Törnqvist (3)	Indexes: NIPA Deflator (4)	Ratio (2)/(3) (5)	Implied Deflator (5)*(4) (6)	Real Consumer Durables (1982 $): This Study (1)/(6) (billions) (7)	Real Consumer Durables (1982 $): NIPA (billions) (8)
1947	20.4	66.6	38.3	36.1	1.74	62.7	32.5	56.5
1948	22.9	67.9	39.0	37.1	1.74	64.6	35.4	61.7
1949	25.0	64.5	39.7	36.9	1.63	59.9	41.7	67.8
1950	30.8	63.2	40.4	38.2	1.56	59.7	51.6	80.7
1951	29.9	64.3	41.6	40.0	1.54	61.8	48.4	74.7
1952	29.3	65.1	41.6	40.1	1.56	62.7	46.7	73.0
1953	32.7	63.5	42.4	40.8	1.50	61.1	53.5	80.2
1954	32.1	61.2	40.8	39.4	1.50	59.1	54.3	81.5
1955	38.9	61.5	42.1	40.1	1.46	58.7	66.3	96.9
1956	38.2	61.8	42.5	41.2	1.46	59.9	63.7	92.8
1957	39.7	63.9	44.2	43.0	1.44	62.0	64.0	92.4
1958	37.2	60.8	43.6	42.8	1.39	59.6	62.4	86.9
1959	42.8	60.8	45.5	44.2	1.34	59.0	72.6	96.9
1960	43.5	59.7	45.7	44.4	1.31	58.0	75.0	98.0
1961	41.9	59.8	46.1	44.8	1.30	58.1	72.1	93.6
1962	47.0	59.1	47.0	45.6	1.26	57.4	81.9	103.0
1963	51.8	59.2	47.8	46.3	1.24	57.4	90.2	111.8
1964	56.8	57.9	48.2	47.0	1.20	56.5	100.6	120.8
1965	63.5	57.4	48.4	47.2	1.19	55.9	113.5	134.6
1966	68.5	55.1	48.0	47.4	1.15	54.4	125.9	144.4
1967	70.6	55.5	48.5	48.3	1.14	55.2	127.9	146.2
1968	81.0	56.3	50.5	50.1	1.11	55.9	145.0	161.6
1969	86.2	56.7	51.6	51.4	1.10	56.5	152.7	167.8
1970	85.7	58.8	52.8	52.7	1.11	58.7	145.9	162.5
1971	97.6	60.7	55.0	54.7	1.10	60.4	161.6	178.3
1972	111.2	62.7	55.8	55.5	1.12	62.3	178.6	200.4
1973	124.7	63.1	56.8	56.6	1.11	62.9	198.2	220.3
1974	123.8	66.8	60.2	60.4	1.11	67.0	184.7	204.9
1975	135.4	73.3	65.7	65.9	1.12	73.5	184.2	205.6
1976	161.5	75.8	69.6	69.5	1.09	75.7	213.4	232.3
1977	184.5	77.4	72.8	72.7	1.06	77.2	238.9	253.9
1978	205.6	81.6	77.2	76.9	1.06	81.3	252.9	267.4
1979	219.0	83.0	82.3	82.2	1.01	82.8	264.4	266.5
1980	219.3	90.2	88.8	89.2	1.02	90.6	242.1	245.9
1981	239.9	96.1	95.3	95.7	1.01	96.5	248.7	250.8
1982	252.7	100.0	100.0	100.0	1.00	100.0	252.7	252.7
1983	289.6	102.9	102.8	102.1	1.00	102.3	283.1	283.6

Sources: Column 1: NIPA table 1.1, row 3. Columns 2 and 3: table 12.8 (see sources). Column 4: NIPA tables 1.1 and 1.2, row 3. Column 8: NIPA table 1.2, row 3.

Note: The difference between cols. 3 and 4 is due entirely to the Törnqvist method of aggregation vs. the implicit deflator method.

Table 12.12 Average Annual Growth Rates of Alternative Deflators for Producer and Consumer Durable Expenditures, Selected Intervals, 1947–83

Interval	Producer Durable Expenditure Deflator	Consumer Durable Expenditure Deflator
1947–83	1.41	1.36
1947–60	0.06	−0.60
1960–73	−0.22	0.62
1973–83	5.29	4.86

out just like table 12.4, which converted the new PDE deflator into a new series on real investment in producer durables. The result is an annual growth rate of real consumer durable expenditures of 6.01 percent with the alternative deflators, in contrast to a growth rate of 4.48 percent for the official NIPA series on real consumer durable expenditures. A particularly interesting conclusion in table 12.11 is the consumer durable deflator implied by the new data, displayed in column 6. As seen in table 12.12, the growth rate of this deflator over the postwar period is remarkably similar to the new PDE deflator from column 6 of table 12.4, despite the fact that the former is based on new price indexes for only eleven products, whereas the latter is based on new price indexes for ninety-one unduplicated products.

In short, the results imply that the average prices of both producer and consumer durable goods were essentially constant from 1947 to 1973 and rose roughly 5 percent per year from 1973 to 1983. In contrast, the official deflators imply that the prices of producer durables rose 50 percent faster than those of consumer durables over the full period (4.37 vs. 2.88 percent per year), that PDE prices more than doubled from 1947 to 1973, and that consumer durable prices increased by 57 percent between 1947 and 1973.

12.7 Implications for Shares of GNP and Sources of Growth

Just as we have found that postwar price changes in producer and consumer durable goods have been much more similar with the alternative deflators than with the official deflators, the same conclusion applies to the shares of durable spending in GNP. A familiar fact in the existing NIPA is that the share of consumer durable expenditures has increased substantially over the postwar period, 63 percent as shown in column 4 of table 12.13. Yet there has been virtually no increase in the NIPA share of PDE in GNP, with an increase in column 2 of only 3 percent. In contrast, the alternative deflators imply much greater 1947–83 increases in both investment shares, 178 percent for producer durables and 164 percent for consumer durables. As was true for the capital/output ratios in table 12.8, the denominator of these investment/output ratios is not NIPA real GNP, but rather that official concept of GNP with the addition of the difference between the alternative and the official real PDE and consumer durable expenditure series.

Table 12.13 **Selected GNP Components as a Percentage of Real GNP Adjusted for the Results of This Study, 1982 Base**

	PDE		Consumer Durables		Other Consumption		Other GNP	
	This Study (1)	NIPA (2)	This Study (3)	NIPA (4)	This Study (5)	NIPA (6)	This Study (7)	NIPA (8)
1947	2.58	6.96	3.27	5.30	61.35	57.19	32.78	30.55
1948	2.70	6.94	3.43	5.57	60.00	55.93	33.87	31.57
1949	2.44	5.91	4.00	6.11	60.18	56.59	33.38	31.39
1950	2.62	5.92	4.55	6.70	57.59	54.22	35.24	33.17
1951	2.66	5.66	3.84	5.62	53.48	50.75	40.02	37.97
1952	2.51	5.31	3.56	5.29	53.19	50.62	40.76	38.79
1953	2.53	5.41	3.92	5.59	52.90	50.32	40.65	38.67
1954	2.50	5.13	4.02	5.75	54.90	52.34	38.58	36.77
1955	2.70	5.47	4.67	6.48	54.67	51.96	37.96	36.08
1956	3.05	5.56	4.38	6.08	55.42	52.89	37.15	35.46
1957	3.05	5.54	4.32	5.96	55.82	53.34	36.81	35.17
1958	2.77	4.76	4.21	5.65	57.06	54.96	35.96	34.63
1959	3.00	5.02	4.62	5.95	56.20	54.17	36.17	34.87
1960	3.07	5.00	4.66	5.89	56.41	54.48	35.86	34.64
1961	2.96	4.71	4.36	5.48	56.26	54.52	36.42	35.29
1962	3.13	4.94	4.69	5.72	55.39	53.68	36.78	35.65
1963	3.35	5.08	4.97	5.97	54.84	53.20	36.85	35.76
1964	3.67	5.42	5.25	6.12	54.78	53.20	36.30	35.26
1965	4.19	6.03	5.60	6.45	54.39	52.77	35.81	34.75
1966	4.75	6.45	5.86	6.54	53.72	52.28	35.69	34.74
1967	4.64	6.15	5.77	6.44	53.76	52.46	35.83	34.96
1968	4.80	6.19	6.27	6.83	53.78	52.60	35.15	34.38
1969	5.10	6.47	6.44	6.92	54.33	53.19	34.13	33.42
1970	5.12	6.33	6.16	6.73	56.14	55.02	32.57	31.92
1971	4.94	6.08	6.63	7.18	55.81	54.75	32.61	31.99
1972	5.28	6.42	6.99	7.68	55.66	54.49	32.07	31.40
1973	6.02	7.27	7.38	8.03	54.74	53.55	31.85	31.15
1974	6.60	7.43	6.88	7.51	54.75	53.83	31.77	31.24
1975	5.69	6.62	6.96	7.63	56.93	55.89	30.42	29.86
1976	5.76	6.59	7.67	8.22	56.50	55.60	30.07	29.60
1977	6.51	7.29	8.19	8.58	55.85	55.09	29.44	29.04
1978	7.11	7.79	8.22	8.58	55.04	54.36	29.62	29.26
1979	7.83	8.11	8.31	8.35	54.64	54.44	29.21	29.10
1980	7.69	7.62	7.60	7.72	55.08	55.05	29.63	29.61
1981	7.64	7.58	7.66	7.72	54.60	54.59	30.11	30.11
1982	7.06	7.06	7.98	7.98	56.79	56.79	28.17	28.17
1983	7.16	7.14	8.64	8.65	56.80	56.81	27.39	27.39

Sources: GNP for cols. 2, 4, 6, and 8 is NIPA. GNP for cols. 1, 3, 5, and 7 is adjusted for the new PDE and consumer durables. Columns 1 and 2: table 12.4. Columns 3 and 4: table 12.9. Columns 6 and 8: NIPA table 1.2.

The corollary of the rapid increase in the share of durable goods spending in the new data is, of course, a decline in the share of spending on categories of GNP other than durable goods. This is shown in the right half of Table 12.13. In contrast to the NIPA, in which the share of nondurable consumption falls only by 0.7 percent from 1947 to 1983, in the new data that decline becomes 7.4 percent. The NIPAs already register a substantial 10.3 percent decline in the share of GNP other than PDE and personal consumption expenditures, and this decline becomes 16.4 percent in the new data. In short, durable goods have been the most dynamic component of spending on GNP, and use of the new data to compute new industry productivity measures would indicate that the growth rate of productivity in durable manufacturing has been greatly understated, although by more before 1973 than since 1973.

An important question to ask of the new data is whether they contribute any explanation of the post-1973 productivity growth slowdown in the United States. It seems evident already from the results presented earlier in this chapter that there cannot be a major contribution, simply because the drift of the alternative relative to the official deflators extends over the whole postwar period. The 1947–73 annual rate of drift of the alternative relative to the official deflator (from table 2.1) is 3.3 percent, and a lower 2.1 percent for 1973–83. One would think that a finding of more rapid growth in capital input before 1973 would contribute to the productivity puzzle, since new data showing a greater slowdown in the growth rate of capital input would leave a smaller slowdown in total factor productivity (''Denison's residual'').

This presumption, however, ignores the effect of the new deflators for producer and consumer durables on the growth rate of output; since the growth rate of output is increased more prior to 1973 than after, this implication of the new data deepens the productivity puzzle. The balance between the two effects, a greater speedup of the growth of both output and capital input before 1973 than after 1973, depends on the weight assigned to capital input as a source of growth. Unfortunately, existing estimates of capital's share differ widely. One can find weights for fixed capital input ranging from as low as 20 percent (Denison 1985, table G-2 for 1967) to 41 percent (Jorgenson and Griliches 1972, table 20 for 1962). Here, I take a compromise position and exhibit the effect of this study on the sources of growth when an arbitrary capital share of 25 percent is used. The results, displayed in table 12.14, are set out in a format that allows the results to be recalculated easily for any other assumed income share of capital.

Table 12.14 is arranged into five columns, corresponding to the three standard subintervals, the full 1947–83 period, and the extra 1947–73 subinterval that is of interest in discussions of the post-1973 productivity growth slowdown. Comparing columns 3 and 4, we can assess the effect of the new price indexes on the growth of GNP, capital input, the contribution of capital to output growth (using the arbitrary 0.25 weight), and multifactor productivity (MFP), that is, the growth rate of output minus the contributions of capital and labor input. The line labeled ''Alternative-NIPA'' in the top section indicates that the effect of the new deflators on the growth rate of output is 0.23 percentage points in 1947–73 and 0.26 points in 1973–83, that is, almost exactly the same. The respective figures for capital's contribution to growth are 0.42 and 0.35 points. Using the same series on labor input to compute both alternative and NIPA versions of MFP growth, the new price

Table 12.14 **Effect of Alternative Durable Goods Deflators in Sources of Growth Calculation (annual growth rate over interval)**

	1947–60 (1)	1960–73 (2)	1947–73 (3)	1973–83 (4)	1947–83 (5)
Private GNP:					
Alternative	3.68	4.14	3.91	2.08	3.40
NIPA	3.35	4.02	3.68	1.82	3.17
Alternative—NIPA	0.33	0.12	0.23	0.26	0.23
Capital input:					
Alternative	4.60	5.73	5.17	4.97	5.11
NIPA	3.10	3.87	3.49	3.56	3.51
Alternative—NIPA	1.50	1.86	1.68	1.41	1.60
Capital contribution:[a]					
Alternative	1.15	1.43	1.29	1.24	1.28
NIPA	0.78	0.97	0.87	0.89	0.88
Alternative—NIPA	0.37	0.46	0.42	0.35	0.40
Private business labor hours	0.79	1.93	1.36	1.00	1.26
Labor contribution[b]	0.59	1.45	1.02	0.75	0.95
Multifactor productivity[c]					
Alternative	1.94	1.26	1.60	0.09	1.17
NIPA	1.98	1.60	1.79	0.18	1.34
Alternative—NIPA	−0.04	−0.34	−0.19	−0.09	−0.17

Sources: The difference between alternative and NIPA real GNP is equal to the difference between alternative and NIPA real PDE from table 12.4 and real consumer durable expenditures from table 12.11. Growth rates of alternative and BEA capital stock are from table 12.6. Private business labor hours are from NIPA table 6.11, extrapolated back from 1948 to 1947 by use of full-time equivalent employment from NIPA table 6.7, part A.

[a]Equals capital input times 0.25.

[b]Equals labor input times 0.75.

[c]Equals growth in output minus capital contribution minus labor contribution.

deflators reduce the growth rate of MFP by 0.19 points before 1973 and 0.09 points after 1973. The MFP growth slowdown after 1973 is 1.61 points in the official data and 1.51 points in the new data. Thus, the new data contribute less than one-sixteenth (0.10/1.61) of the needed explanation of the post-1973 productivity growth slowdown.

12.8 Conclusion

This chapter has described the process by which new price series for almost 100 types of PDE have been converted into alternative versions of the PDE deflator, real PDE investment, the consumer durable expenditures deflator, and real expenditures on consumer durable goods. The aggregation process for PDE can be summarized as involving four steps. First, within each of twenty-two PDE categories, the existing weights applied to particular product price indexes (mainly components of the PPI) in the NIPA PDE deflator were used to aggregate both the new product price indexes and the official price indexes with which those new indexes are compared. The NIPA weights applied to uncovered products (i.e., those for which new data is not available) are set to zero at this step.[7] Second, the Törnqvist method rather than the conventional implicit deflator method is used to aggregate alternative and existing official price indexes across the twenty-two categories, using NIPA nominal investment shares in each category as weights. Third, a new deflator for total PDE is calculated by multiplying the alternative/official price ratio for each of the twenty-two categories by the existing PDE deflator. This has the effect of assuming that the ratio of the unobserved alternative price to the official price in the uncovered sector of each category is equal to that ratio for the average of the covered products in the same category. It should be stressed that information on the drift in the alternative/official price ratios is not applied from one category to the uncovered sector of another category. Finally, real investment is calculated by taking the existing NIPA nominal PDE aggregate and dividing by the new PDE deflator.

The final results have radical implications for the price deflator and quantity of PDE. The new PDE deflator rises almost 3 percentage points per annum less than the NIPA PDE deflator, and the annual growth rate of real investment is increased by 93 percent, from 3.2 to 6.2 percent per annum over the thirty-six-year period between 1947 and 1983. The most startling implication of these results is for the ratio of equipment investment to GNP, which almost triples during the postwar period, as compared to rough constancy in the NIPA data. A subset of the new price indexes applies equally well to consumer durable expenditures and is used to replace the official consumer durable deflator for products making up about half of consumer durable spending in 1982. The result is a smaller but still significant reduction in the growth rate of the consumer durable deflator of about 1.5 percent per year, and a corresponding increase in the growth rate of real consumer durable expenditures by the same amount. The study eliminates the differences between the behavior of inflation in producer and consumer durables that is present in the NIPA versions. Over 1947–83 both types of durable expenditures exhibit almost exactly the same rate of price increase in the new data, whereas in the NIPA data the inflation rate for producer durables is about 50 percent faster than for consumer durables. A similar revision is made to NIPA data on shares of durable spending in GNP. In contrast to the official data showing no increase in the share of PDE and a two-thirds increase in the share of consumer durable expenditures, the data imply that the share of both types of durable goods almost triples. Despite the radical nature of these conclusions, they have only minor implications for the puzzling decline in productivity growth since 1973. The 1.61 percentage point deceleration in the annual growth rate of MFP that occurs in the official data is reduced only to 1.51 percent in the new data.

7. The distinction between the sixteen primary categories listed in App. B and the six secondary categories for which duplicate indexes were used, as listed in App. C, is not made in this summary. See sec. 12.2 above.

The main questions remaining at the conclusion of this large research project regard the reliability of the findings regarding the PDE deflator. To avoid duplication, the main discussion of possible biases in either direction is contained in chapter 1. The radical difference between the new PDE deflator and the official series reflects both theoretical and methodological innovations. Capital goods are valued by their contribution to a firm's net revenue, that is, gross revenue less operating cost. Two capital goods are equivalent if they earn the same net revenue, in which case they will sell for the same age-adjusted price on the used asset market. This notion implies that an attempt must be made to value not just the change in performance of new models versus old models, but also any changes in energy use and repair costs. Several of the product categories that exhibit the most radical differences between the alternative and the official deflators treat explicitly changes in operating characteristics, particularly the new indexes for electric utility generating equipment and commercial aircraft. An important validation of the basic theoretical approach comes from the market for used aircraft; a price index that compares new and old models with quality relatives established by their subsequent value on the used aircraft market declines even more radically over the postwar period than an alternative index based on an explicit attempt to estimate net revenue. Adjustments for energy use and repair frequency also are applied for most major consumer appliances.

Most of the innovative conclusions of this study stem, however, not from operating efficiency adjustments but from a consistent implementation of current theoretical practice. The BEA already has a price index for computer systems extending back to 1969; this is confirmed with new data and extended back fifteen years earlier. The undesirable effects of the implicit deflator methodology are repaired by aggregating computers with other products using the much superior Törnqvist method, in which weights for aggregation respond each year to changes in value shares, and in which there is no effect of the choice of the base year. The widely accepted principles used by the BEA for computers are extended to communications equipment, the single most important category of PDE. The single largest body of data, however, comes from the Sears catalog and simply involves the application of the standard BLS specification technique, without explicit efficiency or reliability adjustments, carefully and consistently over a long period of time.

The most likely source of downward bias in the resulting durable goods deflator may occur in the process of aggregation. It is, of course, possible, that the PPI makes errors only in measuring the goods covered in this study, and measures all uncovered goods with perfect accuracy. This hypothesis seems implausible on its face when we consider the similarity between many covered goods and those that remain uncovered. An important uncovered area, for instance, consists of large numerically controlled machine tools that incorporate computerized controls and programming. There are probably very large errors in the PPI for these products, which essentially are combinations of computers with traditional machine tools, and yet I impute to omitted machine tools only the relatively small drift between the new index for covered machine tools and the PPI indexes for the same products. Similarly, large-scale agricultural harvesting and construction equipment is uncovered, and I impute only the very small drift in the new indexes for agricultural and construction machinery, with no impact at all allowed to creep into these categories from the PDE categories that exhibit major differences (e.g., computers and aircraft).

Many of the biases that contaminate the new indexes actually work in the direction of causing them to understate the difference with the existing official indexes. Almost every study in this book has ended with a discussion of unmeasured quality change. Lacking data for the prices of photocopying machines, I use the average of the new price indexes for noncomputer office machine products, which fail to take account of the radical improvement in the reliability of photocopying machines over the past several decades.[8] More important, no account is taken of reduced vibration and noise of jet planes, of improved fuel economy of tractors and outboard motors, of longer lifetimes of diesel engines, of additional features on typewriters and calculators that did not exist a decade ago, of improved handling capabilities of automobiles, of better sound quality for radios, and of better picture quality of television sets. While some of these unmeasured quality improvements influence the value of products for consumers, others make producers' equipment more valuable in ways that would raise their value on the market for used assets.

The value of many of these unmeasured quality improvements is difficult to estimate, but at least we know that they all work in the direction of causing the new PDE deflator to understate the extent of quality change. The opposite bias due to coverage gaps and mismatch between the alternative indexes and particular PPI components is speculative, and even its direction is unknown. With the large number of new price series that are introduced here, there is no doubt that experts at the BLS and elsewhere will be able to raise questions about individual products over individual time intervals. But there is no less doubt that the overall impact of unmeasured quality change is substantial and provides a protective "cushion" that lends credibility and value to the final results.

8. A Xerox repairman told me in mid-1988 that, whereas a repair interval of once each 5,000 copies was common "a few years ago," the average interval on the machine in our economics department was once each 40,000 copies, and even newer machines were averaging once each 80,000–100,000 copies.