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11 Using Unit Value Indexes to Measure Transaction Prices and Quality Change

11.1 Introduction

Up to this point, this book has been entirely concerned with the development of new price indexes for durable goods that are corrected to the maximum extent possible for changes in quality. In addition to quality change, a second issue that has received considerable attention in the price measurement literature is the cyclical sensitivity of transaction prices relative to list prices. Macroeconomists have long been interested in the incredible rigidity of the price indexes for many individual commodities. One of the advantages claimed in earlier chapters for the use of mail-order catalog prices, as well as prices of late-model used automobiles and tractors, is that catalog prices represent actual transaction prices, and that late-model used asset prices should be close proxies for the true transaction prices of new models. An even better source of information on transaction prices comes from the collection of prices directly from buyers, as contrasted to the PPI procedure of collecting from sellers. The well-known book by Stigler and Kindahl (1970) reported the results of a data-collection project in which buyers of industrial equipment were directly approached for price quotes. Another source of information on transaction prices can come from a hedonic regression index if it is based on prices collected from buyers on mail-order catalogs, or on the actual sales prices of late-model used items.

A separate data source, unit values in the Census of Manufacturers, has severe limitations for the study of both secular quality change and changes in the relation of transaction to list prices. Nevertheless, on the basis of an extensive earlier research project, I believe that unit value indexes for several basic and simple industrial goods can provide a useful complement for the other data sources utilized in this book.[1] The two basic weaknesses of unit

1. The earlier research, which was widely distributed in mimeographed form in 1972–73, was included in the first draft of this book in 1974. This chapter extends to 1983 the unit value indexes

value data are that they allow correction for at most one dimension of quality change (e.g., horsepower for diesel engines), and they are subject to spurious movements that reflect changes in product mix rather than true changes in price. The products chosen for analysis in this chapter are one-dimensional in quality, primarily engines, compressors, and condensing units, and have data available in sufficient detail to allow control for changes in product mix along that single quality dimension.

11.2 Background of the Transaction Price Issue

Soon after the inception of the WPI, observers took notice of the incredible rigidity of the price indexes for many individual commodities.[2] Price quotations remained unchanged month after month through prosperity and depression. Accepting the validity of the WPI price quotations, Means (1935) and others cited their rigidity relative to "classically competitive market prices" as support for the proposition that industrial prices are "administered" by firms rather than determined by the interaction of market supply and demand. The implication was not merely that administered pricing was responsible for the relatively large adjustment of real output and small adjustment of prices during business contractions, but also that the entire structure of classical economics had been called into question: "Until economic theory can explain and take into account the implications of the neoclassical behavior of administered prices, it provides a poor basis for public policy. The challenge which administered prices make to classical economics is as fundamental as that made by the quantum to classical physics" (Means 1972, 304).

An alternative explanation for the relative rigidity of some industrial prices is that WPI price quotations are sellers' list prices, which do not reflect actual market conditions. One of the first to suggest this possibility was Stigler in his critique of the kinked demand curve: "It is not possible to make a direct test for price rigidity, in part, because the prices at which the products of oligopolists sell are not generally known. For the purpose of such a test we need transaction prices; instead we have quoted prices on a temporal basis, and they are deficient in two respects. The first deficiency is notorious: Nominal price quotations may be stable although the prices at which sales are taking place fluctuate often and widely" (Stigler 1947). Flueck (1961, 422) offers several reasons why actual market prices might differ from list prices, of which the most important is discounting: "Apparently the most popular and widely used method is to offer discounts of varying degrees (depending on the market supply and demand situation) from the list price which is quoted in

for a subset of eight of the fifty-two products that were studied in the earlier report, copies of which are still available on request.

2. For references to the literature, see Stigler and Kindahl (1970, 11–20).

trade journals, newspapers, by trade associations, and unfortunately for many commodities, the WPI. For discounting appears to be very common in normal markets, rampant in weak (buyers') markets, and zero or negative in strong (sellers') markets."

Evidence on transaction prices would be useful in providing an indication of the accuracy of the conventional PPI commodity indexes. If discounting and premiums are important and vary procyclically, the existing national accounts may understate cyclical fluctuations in prices and overstate fluctuations in real output. New insights may be gained about particular historical episodes, for example, were price controls in World War II and during the Korean War as effective as the official indexes imply, or did the actual transaction prices include premiums? If discounts are important for those commodities with relatively inflexible "administered" PPI quotations, and if PPI quotations in competitive markets are relatively accurate, then improved measures of transaction prices may reduce or even eliminate the contrast between administered and competitive price behavior.

If discounting were equally prevalent in sales of producer and consumer goods, the official U.S. price deflators would be more accurate for the latter, since the CPI is based on field reports of actual retail transaction prices, whereas the primary source of producer good prices, the PPI, relies primarily on reports of list prices mailed in by manufacturers.[3] Several studies, most notably that by Stigler and Kindahl (1970), have attempted to remedy this inadequacy of the PPI by collecting data on actual prices paid by buyers and comparing these "true" quotations with the PPI list prices. Unfortunately, with a few exceptions, these studies have been limited to relatively homogeneous crude and intermediate goods (e.g., steel). Virtually no information is available on transaction prices of finished capital goods.

This chapter reports on an exploratory attempt to analyze evidence on transaction prices of capital goods. The U.S. Census of Manufacturers regularly publishes data on the value and quantity of products shipped, and in some cases these are collected for very narrowly defined commodity classifications. The ratio to quantity shipped, the "unit value," is a transaction price (f.o.b. plant, after discounts and allowances, excluding freight charges

3. In March 1975, according to the Ruggles report (U.S. Executive Office of the President 1977, table 1-5), 98 percent of PPI commodity indexes in SIC industries 34–38 were based on company reports, and of these 95 percent were based on "list prices minus discounts" rather than on "list prices" or on "average realized unit selling price." This still leaves open whether the companies report transaction prices or list prices. Clorety (1970, 34) writes, e.g., that "the WPI for motor vehicles reflects . . . actual transaction prices." And, in general, when "the trade press or other publications report discounting," it is typical "for the appropriate commodity analyst to check the reports immediately with reporting companies and other sources of information. Like quality adjustment, the pursuit of actual transaction prices is virtually a daily problem in calculating the PPI." But my impression, based on the time I spent copying monthly PPI commodity quotations, is that these efforts are sporadic rather than general. Most PPI commodity quotations for machinery remain absolutely fixed for long periods of time, often twelve months or more, suggesting continued heavy reliance on list price reports.

and excise taxes) that can be compared to PPI price quotations for the same products to determine the prevalence of price discounts on capital goods not taken into account in the PPI. Annual unit value data are a potentially valuable yet almost untapped source of information, and as many as twenty-four annual observations are available for some products.[4] The basic hypothesis to be tested is that the ratio of census unit value to PPI price for a given commodity fluctuates procyclically, indicating an increase in the prevalence of discounting in weak (buyers') markets.

The unit value indexes developed in this chapter can do "double duty," both serving as an indication of cyclical fluctuations in the ratio of transaction to list prices, and providing alternative quality-adjusted price indexes to add to those developed in the previous chapters of the book. A basic flaw of unit value data is that changes in unit values may indicate either changes in prices or changes in the size/quality mix. Unit value data for some products (e.g., "standard nonelectric typewriter") are collected with absolutely no information available to estimate the importance of shifts in quality mix. Others are collected in "cells" differentiated by a major quality characteristics (e.g., horsepower for diesel engines). If the single quality dimension along which the cells are differentiated also happens to be the dominant quality characteristic of the product, then use of unit value indexes as a proxy for quality-adjusted price indexes may be possible. If, however, there are multiple dimensions of quality, then unit value indexes will not be up to the task. For this reason, coverage in this chapter is limited to only eight products that perform fairly simple tasks and for which the assumption of a single dimension of quality should be valid. These are cast iron radiators, gasoline and diesel engines, and several types of compressors and condensing units. In an earlier version of this study, many more products were included, but previous chapters have now developed evidence for many of these (e.g., tractors) that corrects for multiple dimensions of quality change.

11.3 Conceptual Problems in the Use of Census Unit Values

11.3.1 Previous Critiques

The U.S. Census Bureau collects data on the value of shipments and the number of units shipped for numerous manufacturing commodities, and the

4. Previous studies of unit value data include the following. McAllister (1961) calculated two annual unit value indexes for machinery: standard typewriters (1948–59) and a ½ hp "Jet Type Deep Well Water System" (1952–56).Two other studies are exclusively concerned with the "secular drift" in several unit value/WPI ratios and do not discuss annual changes (Jorgenson and Griliches 1972; and Searle 1970). The Searle report contains two appendices: "A Study of Differences between Census and Price Index Deflators," by Cornelia Motheral and Alexander Yeats (app. A); and "A Study of Census Unit Value Relatives and Comparable Wholesale Price Indexes for Selected Manufactured Products, 1958–1963," by Edward D. Gruen and Mary E. Lawrence (app. B).

unit values (i.e., value shipped divided by number of units shipped) can be compared with PPI quotations. In considering unit value data for narrowly defined individual commodities as potential replacements for PPI quotations, this chapter evaluates the feasibility of a recommendation of the 1961 Stigler report: "Where buyers' prices are not available, we recommend extensive use of unit values, at least as benchmarks to which the monthly prices are adjusted. Unit values are inferior to specification *transaction* prices, but when unit values are calculated for fairly homogenous commodities, they are more realistic than quoted prices in a large number of industrial markets" (NBER 1961, 71).

The Stigler recommendation was later challenged, and the use of unit value data as price quotations has been seriously questioned, by an unpublished report chaired by Allan D. Searle of the Bureau of Labor Statistics, henceforth the "Searle report" (Searle 1970). The report is based on two staff studies that tip the scale against unit values, rejecting the Stigler call for unit values calculated for "fairly homogenous commodities" as unattainable, since even at the census seven-digit product level changes in unit values are dominated by shifts in product mix:

> This [first] study suggested that any gains in precision which may arise because unit values reflect a comprehensive universe representing actual transaction prices are offset by problems of product and transaction mix. This arises because a 7-digit Census product may include a relatively wide range of specifications and transaction types. This mix may change markedly from Census year to Census year. The other study, in depth, of 25 items, at the 7-digit product level, showed a "persistent tendency of unit values between 1958 and 1963 to reflect shifts in product mix, usually to the lower end of the quality—or price line." [Searle 1970, 4]

More recently, Lichtenberg and Griliches (1989) have carried out a wide-ranging comparison of unit value indexes with PPI indexes at the seven-digit product level. Their study was limited to price changes over a single interval, 1972–77. Their major conclusion regarding unit value indexes is that these have a much lower signal-to-noise ratio than the PPIs, 0.53 as compared to 2.72 by their estimate. They estimate that the PPI captures about two-thirds of actual quality change over their period of study. The Lichtenberg-Griliches study confirms Searle's previous verdict that unit value indexes cannot be used as a universal replacement for PPIs, because of the problem of changes in product and transaction mix. However, because their study contains no criterion for selecting the "best" unit values and makes no attempt to correct for shifts in product mix, its negative verdict on a universal, unselected, and unadjusted unit values has no relevance to this study, with its narrower focus on carefully selected and adjusted unit value indexes.

This chapter attempts to minimize the quantitative importance of shifts in product mix by limiting the analysis to commodities that the census subdivides into explicit size cells or classes (e.g., gasoline engines of thirty-six to forty horsepower). Yet, even within commodity groups that are defined as narrowly as this, shifts in product mix may occur. One of the twenty-five commodities included in the second staff study of the Searle report, gasoline engines, is included in the evidence evaluated in the present chapter. The report explains an increase in the ratio of unit values to PPI indexes for large gasoline engines as being due to changes in product mix both across and within size cells.

11.3.2 Adjustments for Changes in Product Mix

I deal with the Searle report criticism in two ways. First, the change from one year to the next in the unit value is calculated separately in each size cell, so that the unit value index is not influenced by changes in product mix across cells. Second, changes in product mix within cells are controlled by using information on changes in product mix in adjacent cells. While there is no X-ray to see what is happening inside individual product classes, a plausible assumption is that class lines are arbitrary, and that any significant changes in product mix within classes are revealed by similar changes in mix between adjacent classes.[5] If we are considering adjacent product cells A, B, and C, for instance, a shift in product mix from items in small-size class A to items in medium-size class B, and from items in class B to class C, should indicate that the average size of items within class B is increasing as well. In another situation, when sales of both border commodity groups (A and C) are increasing relative to the subject commodity group (B), the negative adjustment contributed by the lower border class will roughly balance the positive component of the upper class. A simple product mix adjustment is developed to deal with these cases.[6]

The product mix adjustment will be least accurate in the bottom and top size cells, since only half as much information is available on mix movements in adjacent cells. The inaccuracy may be particularly acute when the quantities sold in the smallest or largest class constitute an important share of the product group, for example, the less than 7 hp gasoline engines that, as the second Searle staff study noted, accounted for a large share of quantities and values in the 1963 census statistics. In a class as important as this, the product

5. Another alternative assumption is that class limits are set so as to place the bulk of production at the center of each class. In that case, the average size within a class might well remain constant, even though there is a shift of production up the size scale. The primary reason for rejecting this possibility is that most shifts in class definitions retain arbitrarily, usually even-numbered boundaries, and combine or subdivide these arbitrary classes when production shifts. For instance, class boundaries may shift from10-20-30-50 to 10-30-40-45-50 as average size increases.

6. The formulas are involved, since they take account of the relative width of each size cell, and are omitted here to simplify the presentation. Intuitively, any changes in the share of total units contributed by units in the two adjacent classes are weighted by the mean relative unit value of each adjacent class and by the width of the cell.

mix index may be virtually useless, because its key assumption of a linear relation between price and quantity changes may be invalid. To deal with the problem posed by the bottom and top cells, an initial test calculates alternative unit value indexes that exclude the bottom and top classes. Where these indexes differ from the indexes that include all classes, the bottom or top class is eliminated. This test leads to the exclusion of all data for gasoline engines from size classes below 11 hp, thus eliminating the main problem to which the Searle report called attention for this product (the only product for which there is any overlap between that report and this chapter). For other products, it was not deemed necessary to eliminate the bottom or top classes, either because they were unimportant, or because the product mix was relatively stable. For instance, in the case of diesel engines, subject of a case study later in the chapter, the value of sales in the smallest size class in the 1970s was only 3 or 4 percent, and so changes in unit value in that size class can have only a trivial effect on the final results.

11.4 Characteristics of the Data and Calculation of Indexes

Current Industrial Reports, which publishes annual and in some cases monthly data on the value of shipments and quantity shipped for individual seven-digit census commodities, is a relatively little-known adjunct to the Census of Manufacturers.[7] The *Reports* covers the industry as completely as the census and is not based on a sample survey, as is the Annual Survey of Manufacturers. Standard report forms are submitted by all known producers of the products listed in each *Report*. The incompleteness of the *Reports* compared to the census lies not in the extent of coverage but in the scope of information provided, which includes only the value of shipments and number of units shipped, while omitting the usual census questions on payrolls, value added, geographic origin, and so on.

Although the *Reports* data represent transaction prices and have the advantage of completeness, the method of their compilation and presentation has posed numerous problems for this study. In order to minimize the heterogeneity of products and implement the procedure for product mix adjustments as outlined above, I require that quantities and values for product groups be subdivided into product classes defined by an explicit size dimension, but the criteria for selecting products to be subdivided by size in the census and *Reports* are capricious at best. Although several types of construction and agricultural machinery and virtually all types of refrigeration and air conditioning equipment are subdivided into explicit size classes, not a single product is included within many important categories of PDE. Many of the products that are subdivided (e.g., moldboard plows) are much less

7. Before 1960, the *Current Industrial Reports* was called *Facts for Industry*. The starting date varies among products; the earliest *Facts* for a few products was issued during World War II.

important than those excluded (e.g., lathes). Even within a product group (e.g., electric motors), the selection criteria have no apparent basis. Some seven-digit product classes consist of the entire production of an item in all its various forms and sizes (e.g., product 3621101, "automobile accessory electric motors"). Yet others are arrayed in many separate size categories, as in the extreme example of nonautomotive fractional horsepower electric motors, for which data are available in forty-one separate classes (e.g., product 3621152, "fractional horsepower motors, alternating current, conventional type shaded pole motors, 3¾ inches in diameter and over but less than 4½ inches in diameter, 1/20 hp and over but less than 1/10 hp").

Just eight product groups are selected for this study, a small subset of the forty-two types of PDE for which data are collected in subclasses with explicit size dimensions. An early version of this study covered all forty-two types, plus an additional ten for which no size classes were available, for a total of fifty-two. Here, however, the scope of the investigation is limited by excluding all those products for which some other source of information is available, or for which quality change occurs on a multidimensional basis. For instance, both criteria lead to the exclusion of tractors. The availability of alternative information from the Sears catalog leads to the exclusion of many others, including electric motors, stationary air compressors, and centrifugal pumps. The multidimensional quality issue dictates the exclusion of complex agricultural equipment (e.g., combines and mechanized corn pickers). The product groups selected for this study, then, are as follows, listed here with their average number of size classes over the period 1947–70 indicated in parentheses:

1. cast iron radiators and convectors, measured in square feet (1);
2. gasoline and other carburetor engines, except automotive, aircraft, and outboard (15.9);
3. diesel and semidiesel engines, except automotive (22.0);
4. compressors, all refrigerants except ammonia, open-type, over 10 hp (9.0);
5. compressors and compressor units, ammonia refrigerants (10.8);
6. condensing units, air cooled, hermetic type (7.7);
7. condensing units, water cooled, open type (15.9); and
8. condensing units, water cooled, hermetic type (8.5).

The unit value indexes are the antilogs of log indexes cumulated from the log changes for each of the eight product groups in each pair of adjacent years between 1947 and 1983, exactly the same procedure used to convert the year-to-year log change in the Sears catalog prices in chapter 10 into price indexes.[8] However, the procedure to aggregate the unit value changes in the

8. Data for water-cooled hermetic condensing units begin in 1952; data on gasoline and diesel engines are not available for 1948 and 1949, so that the first year pair is 1947–50.

individual size cells is superior to that used to aggregate price changes for individual Sears models. In the catalog index, no market share information is available for individual models, and equal weights are applied to aggregate the separate model-by-model price changes into a single price change for that product in an adjacent-year pair. Here, for unit values, we can construct a true Törnqvist index, weighting each log change in unit value in each size cell by the average value share of that size cell in each year of the adjacent-year pair.

The number of separate size cells often changes between adjacent-year pairs as class boundaries shift and alter the number of comparisons that can be made between identically defined classes. Assume, for instance, that the available size classes for a product group in three successive years are as follows:

1963	1964	1965
0.0–7.0	0.0–7.0	0.0–9.0
7.0–10.9	7.0–13.9	9.0–13.9
11.0–15.0	14.0–15.0	14.0–15.0

The 1963–64 growth rate would be calculated for the two classes 0.0–7.0 and 7.0–15.0, while the 1964–65 growth rate would be calculated for the two classes 0.0–13.9 and 14.0–15.0. In each pair of years, the maximum number of homogeneous comparisons is two. Shifting boundaries account for the changing number of class comparisons in each pair of years.

In what sense are the size classes for each product group "wide" or "narrow"? If the largest items of a product were only moderately more expensive than the smallest, even two size classes might be sufficient to control for shifts in product mix, but if a large item in a group is 100 times more expensive than a small item, even twenty size classes will each be quite "wide." We can calculate a measure of width as the ratio of the unit value in one class to that in the next smallest class, averaged with quantity weights over all classes. In the original study, class widths ranged from 1.07 for room air conditioners (a product for which I now have information from both the Sears catalog and *Consumer Reports)* to 16.5 for portable air compressors. Leaving aside cast iron radiators, for which no size classes are available, the average size widths for 1947–70 for the remaining seven products are, in the respective order listed above, 1.25, 1.39, 1.29, 1.24, 1.27, 1.28, and 1.29. Thus, the class boundaries are relatively narrow and are quite uniform across these seven product categories. These seven product classes constitute fully half of all the available products for which class boundaries are of an average width of 1.4 or narrower.

The original study constructed four separate unit value indexes for each of the original fifty-two product groups in order to study the effect of dissaggregation. The indexes are as follows, moving from the most to the least disaggregated.

1. The fully disaggregated index P_1 uses all available size class information, and, in addition, adjusts for estimated shifts in product mix within each class, using information on mix shifts across adjacent classes as described above.
2. Index P_2 uses all available size classes, as does index P_1, but excludes the adjustment for changes in product mix within individual classes.
3. Index P_3 is calculated for half the available size classes; half the class boundaries are "thrown away," and the unit values for the remaining classes are set equal to the sum of values in two adjacent classes divided by the sum of units sold.
4. Index P_4 uses no size class information at all. Unit value is defined simply as the ratio of the total value of shipments in the product group as a whole to the total number of units shipped.

A cross-sectional study of the difference between the growth rates of the indexes revealed that the less disaggregated indexes were more error prone in proportion to the average growth rate of size over time and as a positive function of average cell width. For the products that concern us, with relatively narrow cell widths, there were only minor differences between indexes P_1 and P_2. The results discussed in the rest of the chapter are based on the most disaggregated index P_1 for the period of the initial study, 1947–70. For the update of the study over the period 1971–83, the index P_2 was used in light of the minor difference between P_1 and P_2 in the earlier period.[9]

11.4.1 The Selection of PPI Indexes for Comparison with the Unit Value Indexes

While the unit value indexes for product groups are interesting in themselves, the purpose of this chapter is to compare the behavior of machinery prices as measured by unit value indexes with the NIPA deflator for PDE. Since the NIPA deflators are weighted averages of individual PPI six-digit or eight-digit commodity indexes, the unit values for each of the eight product groups are compared here with the appropriate PPI indexes for the same product groups. Previous studies (e.g., the Searle report) were based on unit values for a few isolated size classes (e.g., gas engines of 81–100 hp) chosen for close correspondence with a particular PPI index for, for example, gas engines of 86–104 hp.[10] Yet this procedure has four flaws.

1. Most important, the census size boundaries do not remain constant, so that the unit values are composed of different sized items in different years.

9. While I would have preferred to calculate a P_1 index for the full 1947–83 interval of the study, the original vintage-1972 computer program designed to calculate the intracell mix adjustment needed for P_1 has been lost in the sands of time and was not judged to be worth the time to reconstruct.

10. This is the size boundary for the largest gas engine priced by the PPI during most of the postwar period, index 11-94-01-04.

2. In some year-to-year comparisons, the 81–100 class is subdivided into 81–90 and 91–100. The use of a combined 81–100 class "throws away" valuable information available to improve the control of product mix shift in some years, if not in all years.
3. The use of unit values only for isolated size classes chosen to correspond with PPI definitions (e.g., 7–10.9 hp, 21–30 hp, and 81–100 hp) discards valuable information on the omitted size classes. Prohibitive compilation cost prevents the PPI from maintaining a separate index for every size class, and the value weights for the omitted classes are imputed to the relatively small number of PPI indexes that are collected, but there is no parallel justification to exclude unit value classes, since the marginal cost of including all published size classes is virtually zero.
4. The use of unit values only for isolated size classes prevents the calculation of the intraclass product mix estimate that adjusts unit value index P_1.

Since each product group unit value index in this study contains all available size classes, the most appropriate comparison is the PPI index used in the NIPA PDE deflator to deflate the value of production for that product group as a whole. In some cases, appropriate four-digit or six-digit PPI group indexes are readily available that correspond perfectly to the unit value product groups (gasoline and diesel engines). In the important "service-industry equipment" industry (refrigeration equipment), unfortunately, there are no PPI indexes collected at all for most of the product groups, and the unit values are compared with the proxies selected in the national accounts.[11] A detailed list of the specific PPI commodities chosen for comparison is contained in Appendix table B.17.

11.5 Tests of Cyclical Behavior

11.5.1 Review of Previous Techniques

The previous literature contains a few attempts to test the cyclical relation between transaction and list prices. In most cases, very small sample sizes have precluded formal statistical analysis and have required other expedients.

1. McAllister compared the year-to-year change in the unit value/PPI ratio for steel with the simultaneous change in the steel industry rate of capacity utilization. He found the expected positive correlation on average for 25 steel products in "5.2 out of a possible 10 times" and concluded "clearly, the data as analyzed in the above fashion do not substantiate the hypothesis that the unit values are more flexible on an annual basis than the PPI prices" (1961, 400).

11. Proxy indexes used in the national accounts are listed in App. table A.1.

2. A staff study in the Searle report (1970, 15–24) included cross-sectional regressions within each two-digit manufacturing industry, with the 1963 difference between unit value and PPI commodity indexes (1958 = 1.00) as dependent variable and the change in output between 1958 and 1963 as an explanatory variable. The relation was significant in only seven of eighteen industry groups, and in almost all cases the sign of the estimated coefficient was negative rather than positive.

3. In their study of prices paid by buyers, Stigler and Kindahl compare the average rate of change of their buyers' price index with that of the corresponding PPI series over NBER reference cycles, both before and after correction for trend. On balance, they concluded that the behavior of the PPI and buyers' indexes "uncorrected for trend are essentially identical in their behavior," and "on balance we found slightly better conformity of prices and business changes in contractions than in expansions prior to trend corrections" (1970, 63).

11.5.2 Regression Specification

Because it can allow automatically for the differing length and strength of cycles, because lagged variables can be easily introduced, and because the statistical significance of results can be easily evaluated, time series regressions are preferable to the cycle-average technique. The small sample sizes that have inhibited time series regression studies carried out in the 1960s are no longer an impediment. The model to be tested is that the unit value index P_1 of a product group differs from the PPI index for that group (I) both in its secular trend and in its response to variations in the excess demand for commodities (E) over the business cycle:

$$\log(P_{1t}/I_t) = \alpha_0 + \alpha_1 t + \alpha_2 \log(E_t) + \epsilon_t , \tag{11.1}$$

where ϵ_t is the error term, and the basic cyclical hypothesis is that the coefficient α_2 is significantly greater than zero. The sign of the time trend parameter α_1 cannot be specified a priori, since either the unit value index or the PPI could do a better job of controlling for secular quality change. Equation (11.1) closely resembles a model of price behavior frequently employed in time series studies of aggregate economy-wide price data, in which the aggregate price index (in level or difference form) is regressed on "standard" unit labor cost and a measure of excess demand like E above. In (11.1), the PPI variable (I_t) already incorporates the influence of cost and at least a portion of the effect of excess demand, and so the cyclical hypothesis to be tested is that there is an additional effect of excess demand present in P_{1t} over and above that present in I_t.

The most difficult step in the implementation of (11.1) is the choice of a specific variable to stand as a proxy for excess demand. In my own work on aggregate price equations in the early 1970s (1971a, 1975), I found significant demand effects for the ratio of unfilled orders to capacity in durable manufacturing as an excess demand proxy, based on the idea that excess demand spills into both price increases and increases in unfilled orders, and that unfilled orders in a recession should be compared not with the relatively low shipments that are actually being produced but with the potential shipments that could be produced if capacity were fully utilized.[12] This variable is calculated as the ratio of unfilled orders to shipments multiplied by the capacity utilization rate. An exact analog of this aggregate variable is not available for the disaggregated product groups, so I use the ratio of unfilled orders to capacity (F_t) in the nonelectrical machinery industry, SIC 35, estimated as the ratio of unfilled orders to shipments for that industry multiplied by the capacity utilization ratio for all durable manufacturing.[13]

In estimating the regression model (11.1) over the sample period 1950–83, the excess demand and time trend coefficients were allowed to shift after 1968. Also, the excess demand term was initially entered in the form of lags 0, 1, and 2, and only the significant terms were retained for the estimates presented in table 11.1. Equations were estimated for an unweighted average of all eight products, and for three "industry groups", radiators (one product), engines (two products), and compressors/condensing units (five products).

The results, shown in table 11.1, are presented only for the variant that displayed the strongest evidence of a procyclical movement of the P_{1t}/I_t ratio. Significantly positive coefficients on F_t were obtained for at least half the postwar period, either the early period 1950–68 or the later period 1969–83, or both in the case of engines. However, the results are not as strong as they appear, because the low Durbin-Watson statistics for the aggregate and compressor equations indicate positive serial correlation, and inclusion of the lagged dependent variable in these equations reduces the significance of the F_t terms to zero. However, the radiator equation survives a transformation to first difference form, with the lagged dependent variable entered here to correct for negative serial correlation. The engine equation provides the clearest evidence of a procyclical effect, with reasonable elasticities of 0.2 that are highly significant at better than the 1 percent level and stable across the two subperiods. This elasticity estimate implies that in a typical business expansion, when F_t rises by about 50 percent, the unit value index for engines rises about 10 percent relative to the PPI.

12. This ratio was first developed in deMénil (1969).

13. Unfilled orders and shipments data are taken from the 1975 and 1986 editions of *Business Statistics*. These data are not available prior to 1953; the same variables for durable manufacturing were substituted, from the same source. Capacity utilization in durable manufacturing is taken from *Economic Report of the President*, February 1988, table B-51. This variable was not available prior to 1967; the same variable for total manufacturing was substituted, from the same source.

Table 11.1 **Regression Equations Explaining Ratio of Unit Value Index to PPI, 1950–83**

	Form (1)	Lagged Dependent Variable (2)	Time, 1950–68 (3)	Time, 1969–83 (4)	F_t, 1950–68 (5)	F_t, 1969–83 (6)	$\bar{R}^2$	S.E.E.	Durbin-Watson
Aggregate	Level	. . .	−4.42**	0.00	0.09	0.17**	0.949	5.88	0.67
			[13.79]	[0.14]	[1.39]	[3.28]			
Radiators	First Difference	−0.58**	−1.43	3.45	0.00	0.50**	0.501	5.16	2.14
		[−3.94]	[−1.18]	[1.85]	[0.13]	[4.46]			
Engines	Level	. . .	−4.45**	−1.32**	0.21**[a]	0.18**[a]	0.973	5.46	1.65
			[16.47]	[−4.48]	[3.25]	[3.12]			
Compressors/condensing units	Level	. . .	−5.27**	0.00	0.11	0.26**	0.910	8.77	0.47
			[−11.03]	[0.65]	[1.20]	[3.25]			

Note: Initially, the F_t variable was entered in the form of lags 0,1, and 2 in levels or 0 and 1 in first differences. Each coefficient on F_t shown here is on the current (0) variable only, except for those designated by [a], where the figures shown are the sums of coefficients on lags 1 and 2, with lag 0 omitted. t-ratios are in brackets.

**Indicates significance at the 1 percent level.

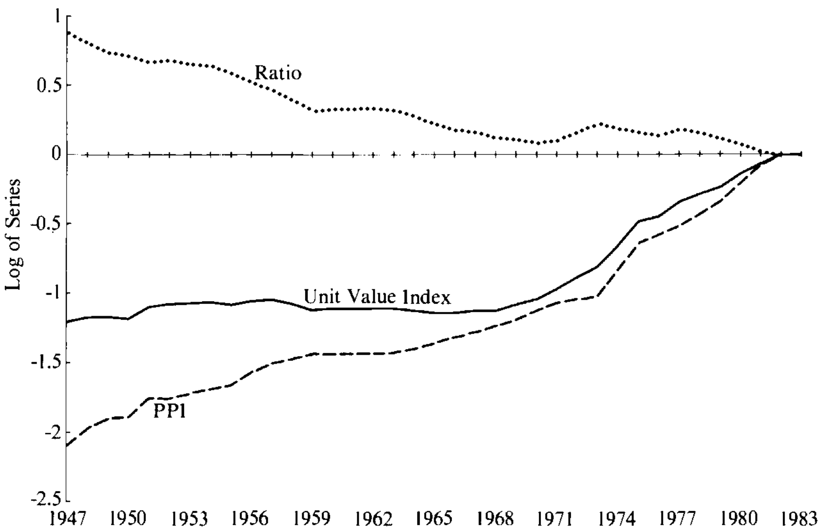

Fig. 11.1 Comparison of price indexes, this study and PPI, 1982 = 1.0

11.6 Secular Drift in the Unit Value Ratios

Another interesting feature of the regression estimates is an extremely large and significant negative coefficient on the time trend variable in the pre-1969 period. The strong downward drift of the aggregate unit value index relative to the PPI (both calculated as an unweighted Törnqvist index of the eight product indexes) is evident also in figure 11.1. As shown by that figure, and evident when growth rates are calculated over three periods (1947–60, 1960–73, and 1973–83), there was a hiatus in the downward drift in the middle period, followed by a resumption of the downward drift in the third period at a much slower rate than in the initial period.

The tendency of the unit value indexes to drift down relative to the PPI, particularly in the 1947–60 interval, applies to all the products except for radiators. While the rates of drift for several products in the compressor and condensing unit group are rapid, the most interesting evidence is for diesel engines. The diesel engine unit value index may indicate convincing evidence of secular bias in the PPI, both because it is so precisely matched to the PPI group index for nonautomotive diesel engines, and because the unit value index for diesel engines is based on so many different size cells (twenty-two, the most for any product in this study or in my broader initial study). Because of the importance of the product and the high quality of the comparison, the unit value and PPI indexes for diesel engines are compared in figure 11.2.

11.6.1 Unit Values as a "Signal" of Unmeasured Quality Change

In addition to their usefulness as indicators of cyclical fluctuations in transaction prices, unit value indexes can also perform a secondary function

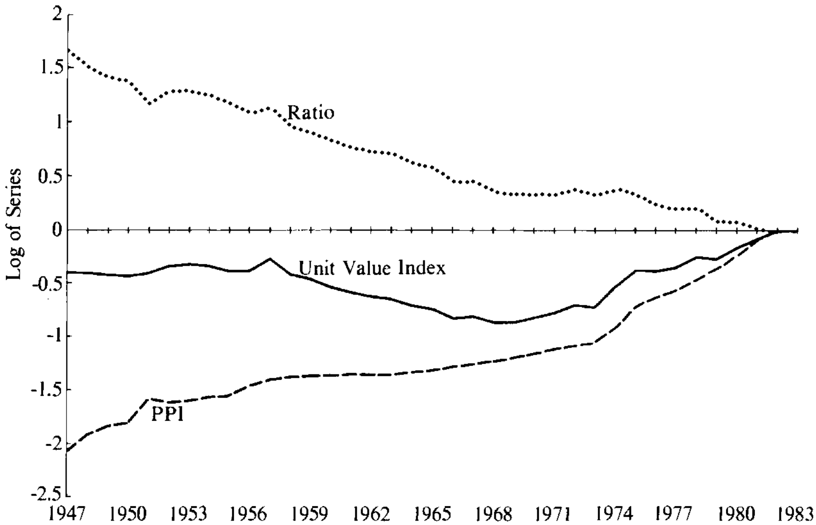

Fig. 11.2 Comparison of price indexes, this study and PPI, for diesel engines, 1982 = 1.0

as a "signal" when they deviate to a very great degree from comparable PPI indexes. A discrepancy might be due to flaws in either the unit value or the PPI and can signal an area in which a search of a third independent outside source of information may yield a high research payoff. The marked discrepancies between unit values and national income accounts deflators for diesel engines, compressors, and condensing units are evident in the regression study above and suggest an inappropriate choice of deflators in the national accounts. Unit values would be particularly good substitutes for the PPI for these products, because census size classes are defined very narrowly in most cases, and the products are simple utilitarian items free from complications of unmeasured quality attributes (with the possible exception of improvements in energy efficiency, which presumably cause the unit value indexes developed here to overstate the true rate of price increase).

This section examines outside evidence for two product groups that display large discrepancies between unit value and PPI indexes. The first is for diesel engines, where the quality of the unit value index is relatively good. The second is for ten-key adding machines, based on a unit value index developed in the earlier study but not used in the alternative price index developed in chapter 12, since we already have the Sears catalog index for ten-key adding machines from chapter 10.

11.6.2 A Case Study: Diesel Engines

The difference between the behavior of the unit value and PPI indexes for diesel engines can only be described as enormous, as shown in figure 11.2. Between 1947 and 1972, the PPI increases by 150 percent, while the unit

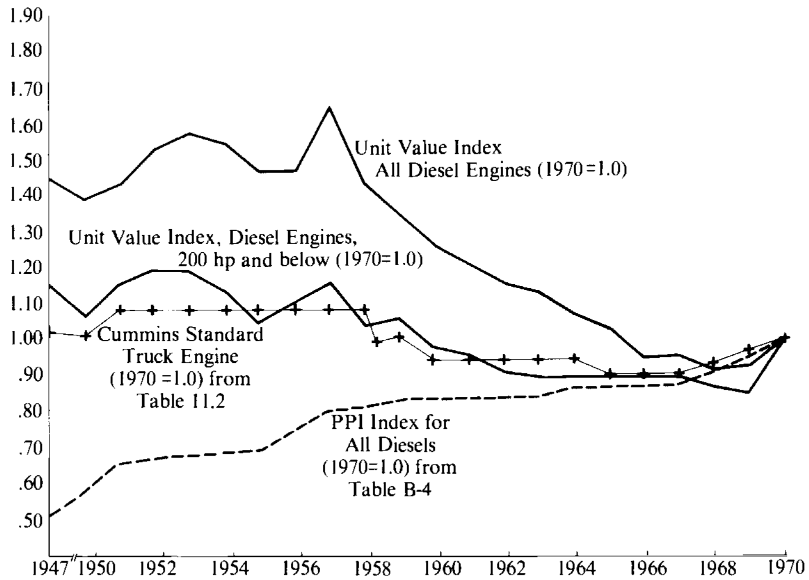

Fig. 11.3 Alternative price indexes for all diesel engines and for medium-sized diesel engines, 1970 = 1.0

value index declines by 25 percent. The unit value index, in addition, exhibits considerably more year-to-year variation than the PPI, and the unit value/PPI ratio in the regression study has a statistically significant correlation with the ratio of unfilled orders to capacity in nonelectrical machinery. Unfortunately, mail-order catalog houses do not sell new diesel engines, and there is no easily accessible alternative source of data on engine prices.[14] In this section, scattered pieces of information are examined that provide most if not all of the needed explanation of the puzzling behavior of the unit value/PPI ratio.

The unit value data for diesel engines are especially useful because so many different size classes are defined in the census, and these allow us to examine disaggregated information to pin down the source of the unit value/PPI puzzle. First, separate unit value indexes are calculated for "small" and "large" engines, with a dividing line selected so that half the size classes fall in each group. The dividing line falls fairly consistently at 200 horsepower, and the index for engines below 200 horsepower is displayed in figure 11.3 as the lower of the two solid lines. Unit values of small engines dropped only 14 percent between 1947 and 1970, as compared to 55 percent for large engines. The impression conveyed by the PPI subindexes is diametrically opposite. The respective rates of price increase between 1947 and 1970 were 76, 109,

14. Warshawsky, a Chicago mail-order automotive catalogue firm, sells a few models of *used* diesel engines, but their condition and mileage differ from one sample to another.

Table 11.2 **Manufacturers' Price Data for Diesel Engines, 1945–75**

	Cummins VT12			Cummins "Standard" Truck Engine			Electromotive "Standard" Locomotive Engine		
	Price (1)	Hp (2)	Price/Hp (3)	Price (4)	Hp (5)	Price/Hp (6)	Price (7)	Hp (8)	Price/Hp (9)
1945				2,690	200	13.4			
1950							33,600	1,650	20.4
1951				2,867	200	14.3			
1955	9,255	600	15.4				39,250	1,925	20.4
1958	9,000	600	15.0	3,160	220	14.4			
1959				2,975	220	13.5			
1960				2,800	220	12.7	37,800	2,650	21.8
1965				2,899	230	13.8	64,200	2,750	23.4
				3,050	250	12.2			
				3,410	275	12.4			
				3,685	335	11.0			
1967				2,750	230	11.9			
1970	9,757	635	15.4	3,051	230	13.2	77,000	3,300	23.4
				3,400	250	13.6			
				3,900	280	13.9			
				4,125	330	12.5			
				4,375	350	12.5			
				4,875	370	13.2			
1975				4,325	230	18.8			
				4,850	250	19.4			
				4,860	280	17.4			
				5,915	350	16.9			
				6,600	400	16.5			

Sources: Obtained by telephone from internal company data. Cummins data verified and extended for the period 1965–75 by letter from company officials, 10 April 1975 (see text). Columns 4–6 refer, respectively, to the NH-220 line in 1965, the NHC-250 line in 1970, and the NTC-290 line in 1975. These were chosen by company officials as "most representative."

Note: Blank space indicates data unavailable.

and 72 percent for the three "small engine" indexes included in the PPI, and an incredible 207 percent increase in the one index for a "large" engine.[15] To simplify the discussion, let us deal with small and large engines separately.

Three leading manufacturers of diesel engines were contacted to obtain further information on price movements. To minimize the burden on the respondent, and because the major puzzle regards secular rather than cyclical movements, prices were obtained only for scattered years and not in the form of an annual series. Prices of three engines are displayed in table 11.2. The first engine listed, upgraded from 600 to 635 horsepower, is used primarily in "off-highway" vehicles (e.g., front-end loaders and other construction and mining machinery). The second is for Cummins's truck engines. Prices are for

15. The horsepower specifications of the three "small" indexes in 1957 were 56–75, 120–190, and 147–200 hp. By 1970, the specifications had shifted to 50–99, 101–200, 200–399, and "over 600" hp.

models chosen by company officials as "most representative," and for 1965, 1970, and 1975 it was possible to obtain price quotes for the entire horsepower range of these model designations.[16] The third is the standard locomotive engine sold by the Electro-Motive Division of General Motors, which until the early 1980s was the dominant manufacturer of diesel electric locomotives. This engine, which was gradually upgraded from 1,605 to 3,300 hp between 1950 and 1970, is also widely used in inland marine use (e.g., tow boats on the Ohio River), for standby emergency power generation, and in oil well drilling.

The first of the three indexes, for the 200–300 hp Cummins truck engine, is exhibited in figure 11.3 and appears to be in extremely close agreement with the unit value index for engines below 200 hp. Both series show virtually no change between 1947 and 1970; the price per horsepower of the truck engine was $13.40 in 1947 and $13.20 in 1970 (after reaching a low point of $11.90 between 1965 and 1967). Unfortunately, only three prices were obtained for the 600–635 hp engine, but there also appears to have been no secular change in price per horsepower ($15.40 in both 1955 and 1970). The locomotive engine increased in price per horsepower by 14 percent between 1950 and 1970, far below the 207 percent increase in the PPI for large engines.

Thus, the first answer to our puzzle is that the PPI is simply inconsistent with historical data provided by manufacturers. The secular rate of change of the unit value index for engines below 200 hp is much more consistent with the manufacturer's information than is the PPI, which is based on questionnaires submitted by manufacturers! It seems unlikely that the price behavior of the particular models selected for the PPI questionnaire could be sufficiently different from the particular models in my unofficial survey to account for the discrepancy. The only plausible explanation is that the PPI must price the same model year after year without taking account of the gradual upgrading of horsepower that typically occurs. For example, the Electro-Motive standard locomotive engine, model 567, retained the same basic appearance and model number as it rose in horsepower from 1,650 in 1950 to 2,750 in 1965 (the 1970 quotation is for the new model 645).[17]

16. The Cummins price and horsepower data were originally obtained by telephone in 1972. Company officials reviewed the draft of the 1974 version of this case study, verified the data, and added supplementary data for 1965–75, as shown in table 11.2. This is contained in a letter with attachments from D. L. Clark and J. H. Seltzer of Cummins, 10 April 1975. This is referenced subsequently as the "1975 Cummins letter." The Detroit Diesel Division of General Motors was also contacted but did not provide a specific price series. They did confirm that the Cummins series was consistent with their experience. Robert Lipsey also provided me with the prices of eleven diesel engines in the 90–263 horsepower range for various years within the 1953–64 period. The average 1953–64 price change for the two models available over that span was −4.4 percent, as compared to −14.7 percent for the Cummins price/horsepower ratio for 1951–65 (table 11.2), where the 1965 figure is calculated as the average for all models shown.

17. The exact horsepower figures were obtained in a telephone conversation with H. L. Smith, chief engineer of Electro-Motive, McCook, Ill. Further evidence on price changes for locomotives is provided in chap. 9.

Table 11.3 **Dimensions of Quality Improvement in Automotive Diesel Engines, 1931–75**

General dimensions of improvement:

1. Since 1945, product line has been through a complete evolution. We are selling completely different products today.
2. While this product evolution occurred, it allowed the trucking industry to upgrade from approximately 150 hp in 1945 to 250 hp in the late 1960s and on to over 300 hp in 1974.
3. With the introduction of turbochargers and improved fuel systems on our products, they now have both higher output and better fuel consumption characteristics.
4. The durability (or life to overhaul) of our products has been increased by nearly a factor of three since 1945. That is, engine life which was below 100,000 miles is now around 300,000 miles.

Examples of specific product evolutions:

1931	"H" series engine (672 cubic inches) introduced. 150 hp at 1,800 rpm.
1944	"HR" series engine (743 cubic inches) introduced. Added fully counterweighted crank and vibration dampers, allowing 2,100 rpm. 180 hp at 2,100 rpm.
1945	"NH" series engine (743 cubic inches) introduced with 4 valve heads versus 2 valve previously. 200–220 hp at 2,100 rpm.
1954	Turbocharged versions introduced allowing increased horsepower. 335 hp at 2,100 rpm.
1954	The "NH" series had its displacement increased to 855 cubic inches. Power range extended to 370 hp at 2,300 rpm.
	New PT fuel system added to product line in the mid-1950s.
1960s	Continuous product evolution extending the life and reliability of products. Includes improved gaskets; cylinder liner designs and materials upgraded; piston designs and materials upgraded; improved piston rings; fillet-hardened crankshafts and improved bearings; alloyed cylinder blocks; improvements in fuel pump and injectors.

Source: Company letter, 10 April 1975 (see text).

Direct evidence that the PPI obtains price quotations for obsolete items and fails to correct for quality change is provided by a manufacturer that is a major source of PPI data in this category. As of 1975, the model priced in the PPI was not the most representative model, but rather the previous line, which was still in production but with diminished market share. The manufacturer concludes that the PPI "does not reflect the dramatic technical improvements in diesel engines" and provides the information contained in table 11.3 as "the primary factors which it [WPI] doesn't account for." In contrast to the 150 percent increase in the PPI registered between 1947 and 1972 for diesel engines, the manufacturing official concludes, "while these improvements [listed in table 11.3] added cost to our product and resulted in dramatic improvement in product performance, cost reductions in other areas and productivity allowed us to hold prices nearly stable."[18] While, strictly speaking, the unit value and the PPI data are for nonautomotive (i.e., nontruck) diesel engines, while the data in table 11.3 are for automotive diesel engines, the manufacturer states explicitly that the same improvements have been applied to nonautomotive diesel engines.

18. All quotes in this paragraph come from the 1975 Cummins letter.

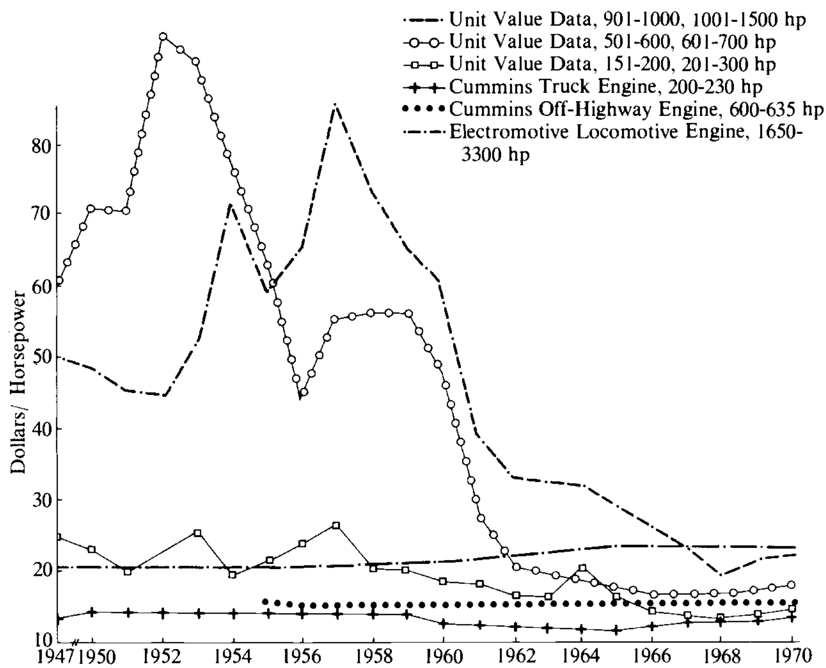

Fig. 11.4 Price data for large diesel engines

However, there is still the remaining puzzle that even if the secular trend of manufacturers' prices corresponds closely to the unit value index for small engines, this leaves unresolved the large discrepancy between the stable manufacturers' prices and the very rapid decline of unit values for large engines. Figure 11.4 illustrates the dramatic narrowing of unit value per horsepower for large and small engines through 1970. Unit values per horsepower are all in the \$14–\$24 range in the late 1960s but ranged as widely as \$22–\$100 in 1952. In the late 1960s, the unit values per horsepower of large engines are quite close to the prices per horsepower quoted by manufacturers, but in the early period are several orders of magnitude higher. My hypothesis is that the decline in unit value per horsepower for large engines was due to a shift in product mix at a given horsepower level from large, heavy, slow-speed engines to lighter high-speed engines with a much lower price per horsepower. This could not be treated as a price decline if there was also a shift in the composition of users from those who are limited to low-speed engines (e.g., because of less vibration) to those who can take advantage of high-speed engines. But, on the contrary, I conjecture that the composition of users remained stable, while engineering improvements in the durability and vibration characteristics of high-speed engines made them available to users who formerly had no choice but to buy low-speed engines.

While there are no detailed data on the end-use composition of diesel purchasers, this conjecture is supported in conversations with industry experts. One official, for instance, reports that "the market for tugboat and barge engines was formerly dominated by the large very slow-speed high price-per-horsepower engines of Waukashaw, Sterling, Alco, and others. Then large firms like Cummins came along and adapted their lighter, higher speed engines for these uses and took away the market.[19] Commenting on this quote, a Cummins official responds that his company had made "measurable inroads into this market previously dominated by slow speed engines, but . . . slow-speed diesels still account for approximately 40 percent of this market." Further support is offered by another expert, who reports that locomotive diesel engines are now used in a substantial number of Ohio River barge tow boats.[20]

The hypothesis is also consistent with the history of the technical development of the diesel engine, which has been marked by a steady and continuous reduction in engine weight per horsepower of output, from 250 lb/hp in the early 1930s, to 45 lb/hp in the late 1940s, to 28 lb/hp in 1960 (Rice 1946, 3; Taylor 1962, 14, fig. 3). In the early period, high-speed engines were plagued by vibration, low durability, and high maintenance cost, but these problems were gradually solved: "Prior to 1936 . . . a large part of diesel development was accomplished at the level of the slow-speed or medium-speed diesel. Not until the 1940s did the high-speed diesel receive a full measure of attention" (Rice 1946, 7).

Nor is the hypothesis inconsistent with Kravis and Lipsey's (1971, 16) cross-sectional regressions, which yield a significant positive coefficient on weight when horsepower is held constant. Further verification comes from the fact that Caterpillar price per horsepower ratios for their 1,300 rpm engines are 1.5–2.0 times those for their 2,200 rpm engines at nearly identical horsepower ratings.[21] Clearly, large, heavy engines have always cost more per household than lighter models, and undesirable characteristics of the lighter models have yielded users sufficient utility to lead them to buy the heavier types. But technical advances have steadily reduced these undesirable characteristics and have allowed more and more users to shift from the heavier to the lighter types. As far as these users are concerned, "best-practice" price per horsepower declines dramatically when they are able to make the switch.

A final factor adds plausibility to the declining relative price of large engines and argues against acceptance of the PPI indication that the relative price of large engines has increased. This is the simple fact that the average size of diesel engines more than doubled from 98 hp in 1947 to 205 hp in

19. Telephone conversation with Raymond Prussing of the Pricing Office, Detroit Diesel Division of General Motors, 13 July 1972.

20. Telephone conversation with H. L. Smith, chief engineer of the Electro-Motive Division of General Motors, 8 August 1972.

21. Letter to the author from D. L. Clark and J. H. Seltzer of Cummins, 10 April 1975.

1970.[22] The misleading impression conveyed by the single PPI index for large engines is a particularly dramatic example of the often-cited "new model" problem. The PPI has continued to price as its only large engine a low-speed model, which my hypothesis suggests has become less and less typical of the average large engine sold. As the relative price of low-speed engines has increased, users have shifted from the item priced by the PPI to lower-priced items that are not in the PPI sample.[23]

Many of the product studies in other chapters have concluded by listing dimensions of quality change that could not or have not been taken into account. Here the most important by far is the tripling of durability cited in table 11.3. If we were to redefine the basic unit of quality of automotive diesel engines as the "horsepower mile" instead of plain horsepower, we would conclude that price per unit of quality fell by two-thirds between 1947 and 1970. This seems the clear implication of the evidence gathered in this section, but in the absence of more detailed model-by-model information on durability, I omit any correction for this improvement. Instead, the durability issue is added to numerous other unmeasured dimensions of quality change recorded in previous chapters that stand as evidence that these new durable goods price indexes, no matter how radical they may seem, understate the required extent of correction for quality improvement.

11.6.3 Case Study: Ten-Key Adding Machines

The earlier and more complete version of the study of unit value indexes developed the unit value index for ten-key adding machines displayed in figure 11.5. I have not included this unit value index in the final price index developed in chapter 12, because there is a satisfactory Sears catalog index that can be used in its place. But here the main focus is on unit value indexes. A comparison of the Sears catalog index previously developed in chapter 10 with the unit value index displayed here helps to demonstrate the usefulness of unit value indexes in signaling problems with the PPI.

How can we account for the incredible 6.4 percent annual rate of decline of the unit value index relative to the PPI for ten-key adding machines? One possible problem is the often-cited lag in the introduction of new products in the PPI. There was no separate index for ten-key machines in the PPI until January 1960, and before that date the PPI (and the national accounts) represent all-electric adding machines by an index for the obsolete full-keyboard models, which accounted for only 24 percent of sales in 1960,

22. This fact comes from the size averages implied by the unit value data. The 1975 Cummins letter contains an exhibit showing an increase in average horsepower of diesel engines sold by Cummins from 215 hp in 1962 to 310 hp in 1974.

23. Concluding its review, the 1975 Cummins letter states that, "although working from limited data and understanding of the diesel engine industry, Professor Gordon has drawn fundamentally valid conclusions concerning the 'unit value' trends over the long term."

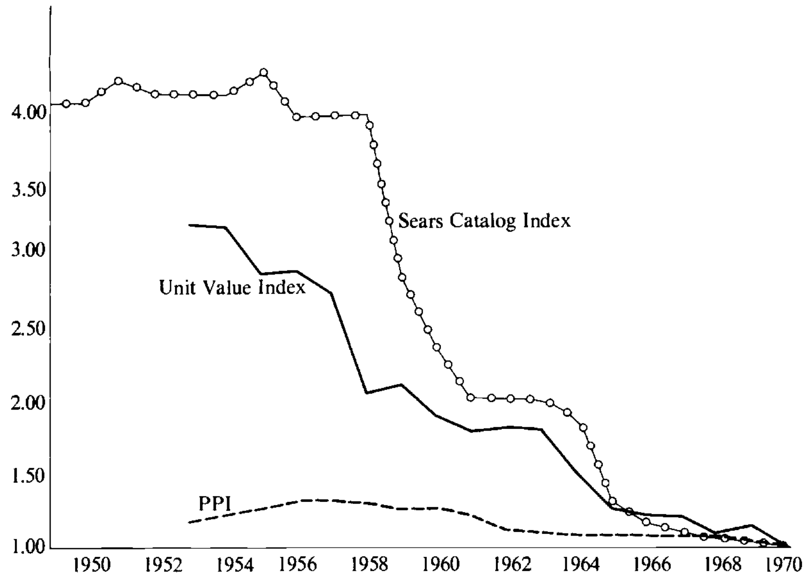

Fig. 11.5 Alternative price indexes for ten-key adding machines, 1970 = 1.0

compared to 76 percent for the ten-key models.[24] Yet this cannot explain the discrepancy, since the unit value/PPI ratio declines by 47.5 percent in the 1966–70 interval when the PPI ten-key index is available, as compared to a 41.5 percent decline in the 1953–60 period.

Chapter 10 demonstrated the usefulness of mail-order catalog price indexes. There we noted that a ten-key electric adding machine with seven digits of display was listed for $285.69 in 1953 and $64.44 in 1970. The only appreciable difference between the two machines was the replacement of metal by plastic casing, which the 1959–60 comparison indicates accounted for no more than $29 of the total $221 drop in price. The catalog index for ten-key adding machines from chapter 10 is displayed in figure 11.5 alongside the unit value and PPI indexes for the same product. The unit value index is strongly confirmed, both in its secular rate of decline and in the timing of the price reductions as concentrated in two episodes, 1957–61 and 1963–65. The major difference is the greater secular rate of decline in the catalog index, perhaps indicating a narrowing of Sears's markup relative to manufacturers' prices, and in the exact timing of the price decline in the 1957–59 interval. Another possibility is that the Sears index accurately measures the true

24. The equivalent sales ratio in 1953 was 54 to 46 in favor of full-keyboard models. The source for these market share data is my file of value-of-shipments data collected for the full unit value study.

transaction price of machines sold by other manufacturers, but that the unit value index declines less in response to an upgrading of the product mix. On the assumption that Sears's prices maintain a rough competitive relation with prices in other retail and wholesale outlets, we can conclude only that the PPI is grossly incorrect as a description of price movements for this product. The unanswered puzzle is the basis of the PPI's information. Perhaps price quotations have been based on the obsolete model with a shrinking share of sales.

11.7 Concluding Evaluation of Unit Value Indexes

The controversy over the use of unit values as a replacement for PPI quotations has developed in two stages. First, the 1961 Stigler report recommended their widespread use and published study papers that contained a few comparisons of unit values and the PPI. The tide was turned by the 1970 Searle report, which recommended against unit values on the grounds that the product mix problem is insurmountable. Previous conclusions of a secular downward drift in unit values relative to PPI quotations in the 1958–63 period were rejected as due to a decline in average size.

The results of this study imply that neither side is correct. Indeed, unit values can be seriously misleading unless explicit size-class information is available for fairly narrow classes. But if this size-class information is available, unit values can serve two useful functions. First, their historical behavior provides valuable information on the importance of deviations between transaction and list prices. Of the eight unit value indexes developed here for products with relatively narrow size cells, convincing evidence of procyclical movements in the ratio of unit values to the corresponding PPI was found only for gasoline and diesel engines. For the other products, the relation did not stand up to detailed scrutiny and testing. This negative finding may be helpful in suggesting that the PPI does *not* understate the cyclical variability of prices, at least for the products studied here. This negative finding would tend to reaffirm previous tests of macroeconomic price rigidity based on official government price indexes.

Second, and more important for this book, marked deviations between the secular rate of growth of unit values and the PPI indexes serve as a"signal" that further research is necessary. In some cases, the PPI may be more accurate and may be confirmed by outside data, and in some cases the unit values may be confirmed. In the two case studies of this chapter, for diesel engines and ten-key adding machines, we have found convincing outside evidence that strongly confirms the behavior of the unit value index and contradicts the behavior of the PPI. It took the outside data to lend credibility to the unit value index; the important function served by unit value data is to pinpoint such areas where further research is likely to have a high benefit-cost ratio.

Remaining unanswered in this chapter is the source of the puzzling behavior of the PPI. The diesel engine case study collected information for the period 1945–75 directly from the dominant manufacturers, which are also the main source of data for the PPI. Their reports deny the validity of the PPI diesel engine index. However, because of confidentiality regulations, there is no way that an outsider can determine the source of the PPI's error. I did make such an attempt in the case of diesel engines, since the evidence reviewed in the case study seems so convincing, and because diesel engines are such an important and basic industrial product. It would have been desirable to examine, for instance, the Cummins questionnaires submitted to the BLS over the period 1947–58, when the PPI states that diesel engine prices doubled, whereas Cummins says they did not change. My request was flatly denied. Further, when I raised the puzzle of the behavior of the PPI for diesel engines with BLS officials, the only information I was able to obtain was the following:

> A review of specification changes for diesel engines reported between 1947 and 1970 shows that there were between 12 and 16 major changes for each of the four non-automotive diesel engines priced for the PPI and two for the truck diesel between 1967 and 1970. Most of these changes resulted from changes in model, speed, horsepower, or other physical product changes which required adjustments to the reported price. We have not made an in-depth analysis of the impact of these changes.[25]

25. Letter to the author from W. John Layng, assistant commissioner, Prices and Living Conditions, BLS, 29 November 1977.

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IV Weighting Issues and Final Results

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