An experimental price index for the computer industry

A pilot study begun in 1987 produced a new price index for computer industry products; chief among the study's findings was that resampling would have to be done over a much shorter time period than the 5 to 7 years now in force for industries covered by the Bureau's existing Producer Price Index

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Recently, the Bureau of Labor Statistics' monthly periodical, *Producer Price Indexes*, began publication of experimental price indexes for the computer industry. Publication of this material was an outgrowth of a pilot study initiated in 1987. The goal of the study was to test a number of different quality adjustment methodologies for developing constant-quality price indexes for the computer industry in an operational environment. More specifically, the project sought to measure the cost improvements embodied in computers and computer peripheral equipment and to develop a methodology for excluding the cost of the improvements from reported prices.

Price indexes should measure only pure price changes and not include the cost of any embodied technological changes. The normal Producer Price Index (PPI) quality adjustment methodology, by itself, was not flexible enough to measure quality improvements in an industry with steadily declining prices. Thus, a new approach was required.

Once the results of the pilot study were evaluated and incorporated into an operational methodology, calculation of comprehensive computer product indexes could begin. This permitted the publication of the experimental index, with its base period beginning in October 1988, in the August issue of *Producer Price Indexes*. This article presents an overview of the experimental computer price index.[1] After discussing how quality adjustment is measured in the PPI program, the article focuses on the level of detail selected for publication purposes, sampling and weighting issues, and the quality adjustment methodology that was ultimately selected. Finally, the current status of the experimental index is examined, together with some economic and statistical issues surrounding it.

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Measurement of PPI quality adjustment

Theoretically, Laspeyres (fixed-input/output) price indexes measure pure price changes for a fixed production mix. In reality, however, many products seldom remain the same over time. Products are always being discontinued, modified, or replaced. The challenge of calculating continuous price indexes in the face of these product dynamics can be met by what we generally refer to as *quality adjustment.*

Quality adjustment in the PPI occurs in three stages. First, the physical changes in the product being priced must be identified. Second, a characterization must be made for each change as to whether it is an improvement or a deterioration, or whether no change in quality has arisen. Finally, each modification that affects cost or functionality must be evaluated in dollar terms.

Because the most appropriate adjustment procedure is critical, four different quality adjustment approaches were investigated during the pilot study. The composite quality adjustment methodology finally selected for the experimental

Table 15. **Industries with largest total employment percentage gain due to various defense cuts in spending**

[Employment in thousands]

Industry	Percent increase from low-defense 1: Number	Percent increase from low-defense 1: Percent
	Conventional cuts	
Guided missiles and space vehicles	142.4	7.2
Radio and TV communication equipment	436.7	1.6
Engineering and scientific instruments	122.6	1.5
Electronic tubes	32.0	1.6
Miscellaneous electronic components	359.3	1.4
Aircraft and missile engines and equipment	370.3	1.3
Aircraft	356.0	1.1
Office and accounting machines	45.6	0.9
Optical and ophthalmic products	74.9	0.8
Semiconductors and related devices	289.8	0.7
	High-tech cuts	
Ship- and boatbuilding and repairing	155.9	20.7
Ordnance, except vehicles and missiles	55.4	15.0
Miscellaneous transportation equipment	50.1	5.4
Engines and turbines	76.9	2.5
Crude petroleum, natural gas, and gas liquids	180.9	0.9
Petroleum refining	105.8	0.7
Pipelines, except natural gas	18.9	0.5
Miscellaneous fabricated metal products	223.7	0.4
Fabricated structural metal products	412.9	0.3
Blast furnaces and basic steel products	244.9	0.2

Table 16. **Occupations with largest employment percentage gain, alternative scenarios regarding cuts in defense spending**

[Employment in thousands]

Occupation	Percent increase from low-defense 1: Number	Percent increase from low-defense 1: Percent
	Conventional cuts	
Aeronautical and astronautical engineers	79.2	1.8
Aircraft assemblers, precision	28.1	1.6
Electronic semiconductor processors	33.8	1 1
Electromechanical equipment assemblers, precision	52.3	0.8
Electrical and electronic equipment assemblers, precision	89.3	0.8
Electrical and electronic assemblers	133.3	0.6
Electrical and electronics engineers	596.4	0.5
Industrial engineers, except safety engineers	152.3	0.5
Coil winders, tapers, and finishers	20.6	0.5
Electrical and electronic technicians	466.3	0.4
	High-tech cuts	
Shipfitters	10.4	16.7
Riggers	13.4	5.5
Painters, transportation equipment	32.8	2.0
Welders and cutters	283.0	1.0
Petroleum engineers	18.4	0.6
Grinders and polishers, hand	73.4	0.8
Boilermakers	24.6	0.7
Gas and petroleum plant and system occupations	22.4	0.5
Painting, coating, and decorating workers, hand	35.1	0.8
All other electrical and electronic equipment mechanics	54.4	0.8

IN SUMMARY, the Bureau has explored several alternatives for future defense spending, in aggregate economic terms and in terms of employment in specific industries and occupational groups. Although the effects tend to be relatively minor at the aggregate level, they may be significant in certain industries and occupations most closely tied to the Department of Defense. While those industries and occupations may suffer from significant defense spending cutbacks, other industries and occupations may improve as a result of offsetting economic factors.

Further efforts could fruitfully be aimed at the estimation of regional effects of defense spending cuts,[4] or by estimating the employment and occupational effects of more narrowly defined cuts.[5] At this point, both the extent and timing of any possible cuts in defense spending are unknown. When the first round of budget-making for the 1990's defense establishment is completed, more narrowly defined approaches might be feasible. □

Footnotes

[1] "Outlook 2000," *Monthly Labor Review*, November 1989, pp. 3–74. This series of five articles on the BLS projections to 2000 outlines the shape of the economy and detailed labor supply and demand.

[2] The estimate of defense-related employment in 1988 was derived by multiplying a 1988 employment-requirements matrix by a detailed vector of Defense Department commodity purchases. An employment-requirements matrix shows the direct and indirect employment in all industries generated by $1 of final production and is derived from a detailed total-requirements input-output matrix and similarly detailed estimates of total industry employment for the year in question.

[3] The initial calculations for each scenario assumed only the change noted in defense spending in order to determine the sensitivity of the aggregate economic model to these changes alone. The aggregate economic projections of the Bureau of Labor Statistics are performed in the context of Data Resources, Inc., Long Term Model of the U.S. Economy. For a full description of the model, refer to "The DRI Annual Model of the U.S. Economy," by Joyce Yanchar, in *Data Resources U.S. Long-Term Review*, Winter 1986–87, pp. 30–43.

[4] This type of regional analysis was presented in "The Peace Economy," *Business Week*, Dec., 11, 1989, pp. 50–55.

[5] For an example of these types of studies, which are just now beginning to appear, see *Budgetary and Military Effects of a Treaty Limiting Conventional Forces in Europe*, a Special Study of the Congressional Budget Office, January 1990.

index blended three specific procedures: The standard PPI resource cost adjustment approach, the implicit regression adjustment approach, and the PPI "cell relative" approach for missing prices. A more detailed explanation of these procedures and how they are applied is given later in the article.

A priori arguments have been made that the PPI indexes have an upward bias due to the absence of accurate quality adjustment information in technologically sophisticated industries. To overcome any such bias, the standard resource cost adjustment approach used in the PPI was the first attempt to value modifications made on selected computer specifications. To implement this approach, a decision strategy for quality adjusting substitute products must include information from computer manufacturers regarding the resource cost estimate (the fixed cost of overhead, costs that vary with output, and any return to the investor—that is, profit) of any improvements or deteriorations. This estimate should reflect the differences in the amounts and kinds of labor and material inputs used in the production of the old and new product. The marginal change in cost is based on "the cost differences in inputs under the cost structure and technological regimen that existed at the time of introduction of the new variety."[2]

The basic underlying assumption of the standard PPI procedure for quality adjustment is that rising resource costs indicate an improvement in quality. Conversely, if resource costs decline, the product's attributes are assumed to be diminishing in quality. Further, if resource costs change for a new product, it must be determined whether the change is in any way a consequence of the product's ability to function differently.[3] As an example in the area of automobiles, the quality changes for which adjustments will be made include "those structural and engineering changes which affect safety, reliability, performance, durability, economy, carrying capacity, maneuverability, and/or comfort and convenience."[4] However, situations arise whereby the manufacturer cannot determine the resource cost of the improvements—for example, when there is a lack of communication of information between engineers and pricing departments, or when there are survey burden requirements. In these instances, the PPI resource cost quality adjustment approach assumes that the entire change between the old and new product is related to quality. The resultant index level then remains unchanged.

Operationally, this selected approach used in the PPI is referred to as a *link to show no change*. Here, the new product is substituted for the old one (after ascertaining that the old product is no longer being manufactured or shipped), and the index level remains the same. In a competitive environment with very sophisticated products, this procedure would introduce an upward bias into an existing index because it would fail to capture the improvement in quality embodied in the new product.

In capital-intensive industries, the majority of the quality improvements are associated with resource cost increases. For those areas in which resource costs and functionality decline, resource cost savings are reported to the Bureau, and prices are adjusted accordingly. However, the computer industry is one of a few exceptional cases. Marked by tremendous improvements in quality at lower costs, it required a better yardstick to value these improvements.

Publication structure

We focused our analysis on product types within the fairly ambiguous classes of machines labeled microcomputers, midsized computers, and large computers. The usual guide for BLS index structures is the Bureau of Census product classifications. Table 1 shows MA35R(87)-1[5] breakdowns for electronic computers, Standard Industrial Classification (SIC) code 3571. From the table, it is plain that dollar values in this industry are not appropriate definers for price index series. Rather, a stable product definer was needed that did not fluctuate with market conditions. For example, midlevel machines,

Table 1. **Value of shipments of electronic computers, SIC 3571, 1987**

[Value in thousands of dollars]

Product code	Product description	Value of shipments
35711	Computers, complete except parts (nonretail)	$23,261,842
	General-purpose computers	
	Digital:	
35711 01	Less than $500 (retail price)	275,532
35711 02	$500 to $1,000 (retail price)	354,833
35711 03	$1,000 to $2,500 (retail price)	2,123,875
35711 04	$2,500 to $5,000 (retail price)	5,019,345
35711 05	$5,000 to $15,000 (retail price)	1,473,348
35711 06	$15,000 to $50,000 (retail price)	3,360,006
35711 07	$50,000 to $250,000 (retail price)	2,770,430
35711 08	$250,000 to $1 million (retail price)	2,639,284
35711 09	Over $1 million (retail price)	1,973,604
35711 22	Analog	} 14,620
35711 25	Hybrid	
	Special-purpose computers	
35711 31	Digital	2,462,140
35711 32	Analog	} 704,825
35711 33	Hybrid	
35711 35	Computers kits to be assembled by purchaser	

often referred to as "minis," had declining prices and were crossing into the high-end "workstation" dollar categories. Based on the competitive conditions in the computer market, the composition of the products that fall into the various categories is always in flux. In addition, if a substitution were required due to product obsolescence, the substitute product's price would probably be different from the base-period product's price. If this were the case, the rule for properly classifying the new product into a specific dollar category would have to be very specific and consistent.

The quality adjustment methodology selected for the experimental index blended three procedures.

The question then arises as to what is a reasonable pricing structure for publication purposes. Both trade and popular press reports provide guidance in the microcomputer area. The personal computer classes, dominated by machines that work alike, or "clones," use the Microsoft/IBM operating system. This system software was originally designed for 16-bit processors from Intel, namely, the 8088 and the 8086. These machines, along with the MS/DOS operating systems, set the standards for hardware and software that still dominate the personal computer market today.

However, there was a significant market for other, more powerful machines. These were most often designed around a 32-bit Motorola 68000 family microprocessor and used a different operating system, usually a Unix derivative. Users of these machines often required multitasking or communication capabilities not possible with the aforementioned 16-bit hardware/software combination. Thus, the different user needs were answered with different hardware/software solutions.

Given the aforementioned considerations, the breakdown selected for the experimental computer indexes was by wordsize, specifically, 16-bit wordsize microcomputers, 32-bit wordsize microcomputers, and computers with a greater than 32-bit wordsize. The only categories we excluded were the rapidly growing laptop computers and the aging 8-bit wordsize computers. We avoided 8-bit wordsize microcomputers for both the pilot and experimental phases, as these mature products would not have provided a rigorous test for our new quality adjustment procedures and are a very small portion of the overall industry. On the other hand, an attempt to include laptops in our resampling efforts for the experimental index will take place for the new sample of products in October 1990. We further categorized processor type where applicable. The implications here are that some parameter estimates are significantly different between the Intel and Motorola classes of processors. Thus, separate modeling efforts would improve the estimated coefficients' quality. Publication and sampling strategies would naturally flow around all these divisions.

Selected methodology

In the absence of information from primary sources, it was our intention to determine cost estimates of product differences in a regression environment that could be made operational inside the PPI. We utilized regression coefficients derived from cross-section estimation equations for the valuation of technological improvements and deteriorations.

Regression analysis is a search for functional relationships among different variables. These relationships are expressed mathematically in the form:

$$Y = b_0 + b_1X_1 + b_2X_2 + ... + b_nX_n$$

The dependent variable Y is the price of a specific computer product. The estimated coefficients b_i represent the change in Y for each unit change in their respective independent variable. The X_i's are the various price-determining or functional characteristics. They may be continuous or discrete dummy variables (0 or 1). The regression coefficients are applied only when product substitution occurs and the manufacturer cannot quantify the improvements in terms of resource cost. For example, if product A is replaced by product B and the marginal change is an increase of two megabytes in main memory, an obvious improvement, the regression coefficient for that computer characteristic within a specific publication category may estimate the dollar value at $925.00. This implicit estimate of the embodied technological change is then deducted from the reported price, leaving a measure of pure price change for the good valued at its base-period capabilities.

The modeling efforts toward developing these implicit prices, just as in the pilot approach, were separated into two phases with respect to data collection: The prefieldwork phase and the postfieldwork phase. The prefieldwork phase provided the basis for sampling decisions, a publication structure, and familiarization with the product. Further, a general sense of how strongly performance characteristic levels influenced the price of a computer was investigated. The postfieldwork regression analysis pooled the secondary-source data base purchased from the GML Corporation[6] with our collected data. We used a dummy variable to differentiate the collected observations from the secondary-source data base.

The methodologies tested separately during the pilot study were ranked into a composite quality adjustment methodology for the published experimental index. Each quality adjustment methodology employs certain strengths. Ostensibly, the composite quality adjustment methodology gives the index maker a measure of freedom among possible alternatives in allowing for modifications in existing specifications. When the PPI resource cost methodology declined in usefulness due to the lack of reliable estimates by the reporter, the regression adjustment estimates were employed. If the regression model did not specify the specific characteristic that changed in the product, we linked to show no change. This composite methodology is best explained by a decision tree:

(A) When a substitute product is available:

(1) Apply producer cost data gathered from the manufacturer;

(2) If producer cost information is not available, use the regression adjustments for valuing the improvement or deterioration in the product; and

(3) If a quality valuation is unavailable from the two previous methods, apply the PPI link-to-show-no-change procedure.

(B) When a substitute is not available, default to the cell-relative procedure.

The procedure described under (A)(3) was used when manufacturers' estimates were lacking and the new substitute item had a characteristic change not specified by the model. In these instances, we applied the PPI link-to-show-no-change procedure if cost adjustments were missed, or we directly compared the prices between the two products if the change had no effect on resource costs.

The decision rule indicated in (B) applies to products that have been dropped from production, are no longer shipped, and have no substitute. In prior years, the PPI program had two procedures for estimating missing prices when reporters were late or delinquent. One procedure simply held the missing price unchanged from its previously reported value, clearly entering a bias of unknown direction, and was dropped from the PPI. The other procedure used the remaining prices of similar products as a proxy for movement of the missing price. This procedure is referred to as the "default estimation method" or "cell-relative method" and was implemented as policy in January 1984. It was felt that the method would have the "least negative impact on the index" and that it should be used when the industry analyst had no further information as to how the price should move. For example, if there were four products in a cell (the most detailed aggregation of published BLS indexes), and one product was no longer manufactured and shipped, the remaining products in the cell would act as the proxy for price movement of the missing product. Other things being equal, the assumption is that substitute products move similarly.

Experimental index sample design

During the pilot phase of the project, we needed a sample of products that would provide a robust test of the various quality adjustment procedures under consideration. It was felt that the competitive nature pervading the microcomputer market would result in frequent model changes. This view was based on our expectation that high-performance systems would have longer development cycles, compared to those of "off-the-shelf" microcomputers, but would then also have a longer market life to recoup their greater development costs. Another rationale for focusing on microcomputers during the pilot phase was that larger computers have a much lower sales volume, potentially making observed transactions more difficult to price. However, for the experimental phase, almost all types of computers were included for measurement.

Attention should be focused on the reporting unit that will ultimately provide the detailed information on products and prices used for calculating indexes. Ideally, the manufacturer selected should have the records necessary to clarify any questions concerning the products included for index calculation. Under the normal sampling strategy used in the PPI program, every potential sampling unit must be given a chance of being selected. To accomplish this objective, a sampling frame must be established that identifies every potential *domestic* manufacturer and provides a measure of size for selecting samples. Because the pilot and experimental indexes were test cases, it was decided that only part of the PPI sampling strategy would be followed, thereby saving time and resources in the research. Normally, sample weights are developed by determining a unit's probability of being selected and a measure of its size (revenue). The measure of size we used was the selected company's value of shipments for the most recent fiscal or calendar year. The unit's probability of being selected, as such, was not used, because our original sample was judgmental in this regard. We therefore asked for four quotes on products from all companies selected that had revenues of less than $10 million, six quotes from companies that had revenues from $10 million to $100 million, and eight quotes from companies that had revenues of more than $100 million, for the latest time period. This distribution of quotes determined the weights for the products within the individual companies selected for

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our experimental index. These weights are referred to as *item weights* and are given by:

$$I_i = 1/U_i \times VOS_i$$

where:

I_i = Item weight for reporting unit i ;
U_i = Number of quotes attempted for reporting unit i; and
VOS_i = Dollar amount of reporting unit's shipments and receipts.

An issue that plagued the project from its inception: when is a computer a computer?

The sampling frame normally used for the PPI program is the Unemployment Insurance (UI) file that identifies domestic establishments that have three or more employees by specific industry, according to the Government's Standard Industrial Classification. The 1972 definition for computers when we began this project was described by SIC 3573, "Electronic Computing Equipment." Unfortunately for our purposes, this 1972 classification structure was all-encompassing in that not only were computers included, but so were storage devices, terminals, magnetic disks, and other peripheral equipment. Consequently, we had to refine the sampling frame to include only those companies dedicated to the manufacture of computers, as identified in the 1987 revised SIC 3571, "Electronic Computers."[7]

In addition to having the UI file combined under the 1972 definition, it was not current enough to select sampling units without augmentation and updating. The time lag in the UI file is approximately 2 years. Therefore, we felt that because the computer industry is replete with rapid exit and entry of firms, we would have to use a more current sampling frame. A GML data file was purchased that apparently had more current information on "microcomputer" companies. For companies that manufactured larger computers, we contracted with GML to provide company-name list prices of characteristics for these domestically manufactured products. We then cross-verified the UI file against the GML data and stratified by domestic manufactures. This gave us our target frame by which to select individual companies.

The normal PPI sampling strategy selects units by ascribing to them a probability proportional to their size. The unit of measure for selecting samples included the number of employees in each establishment. The larger the number of employees in a given firm, the greater was the probability of selecting that firm. Because our research was a test case, we decided to use judgment in the selection of companies for our sample. We knew that by injecting judgment into the selection process, we could not say how statistically representative our sample was of the true population of computer companies. However, we attempted to gain cooperation from as many companies as we could among those already in our PPI program, as well as those never previously contacted. We were pleased to gain the cooperation of 33 computer manufacturers for our experimental index.

The relative importance of the items selected (and their price changes) to one another is highly significant in determining an accurate price index. Not only must weights be developed in the sampling process that proportion items within companies, but they must also be determined for companies within cells. For example, in table 2, "3571–B21—80000 series microprocessor based" is considered a cell.

The cell weights are usually determined from Census Bureau information for individual categories. These weight determinations are needed if one wants to aggregate upward to a less detailed published category. For example, in table 2, "SIC 3571–General-purpose digital computers" is an aggregate of everything under this category. Unfortunately, the Census of Manufactures breakdowns were of little help to us, because they only identified digital, compact, and other computers. Also, the publication *Current Industrial Reports*[8] distinguished categories of computers by dollars, again something that was not very useful to us. As previously discussed, even though the dollar categories listed were by definition mutually exclusive, computers can cross these categories almost monthly because of price changes. Further, identical central processing units sold with different combinations of peripheral devices would be classified into different categories. Once we decided on the cell definitions we would publish, we took the overall dollar weight for SIC 3571 as defined in the 1987 *Current Industrial Reports* and apportioned this weight into our cell categories using a secondary source, namely, the International Data Corporation.[9] This company uses classifications for the industry that are labeled PC, midrange, and large computers.

Definitional and related issues

An issue that plagued the project from its inception was, When is a computer a computer? We asked this question of industry representatives, trade associations, and Government agencies. As anticipated, no uniform response was forthcoming. Some suggested that the proper level of aggregation would be "boards." Others felt that the "box" or processor was the appropriate measure. Still others suggested that the "system" was the key measure because computers are sold as such. (Systems may include a processor, display, keyboard, some storage, and an operating system.) We incorporated the ques-

Table 2. **Experimental price indexes and percent changes for the computer industry**

[October 1988 = 100]

Industry and product	Unadjusted Index			Unadjusted percent change, 12 months ending July 1990
	Code	April 1990	July 1990	
General-purpose digital computers	3571	80.4	79.5	-12.4
16-bit wordsize computers	3571-A	72.5	70.8	-19.5
8000 and 80000 series microprocessor based	3571-A11	72.2	70.6	-19.7
Other 16-bit wordsize computers	3571-A12	97.6	94.4	-6.6
32-bit wordsize computers	3571-B	87.7	87.1	-7.7
80000 series microprocessor based	3571-B21	76.6	74.4	-18.2
68000 series microprocessor based	3571-B22	87.5	87.5	-7.6
Other 32-bit wordsize computers	3571-B23	94.8	94.7	-1.7
Greater than 32-bit wordsize computers	3571-C	84.8	84.5	-6.6

tion into a pretest interview with a number of manufacturers and asked them how they sold their computers to customers. The predominant form in which the computers were sold was as a system. There were exceptions, however, especially as the computer approached the traditional mainframe configuration. In these cases, we accepted the vernacular used by manufacturers in describing a computer. Usually, this meant that the computer consisted solely of a processor with no storage or operating system, items that were considered extras and purchased separately. As a result of the manufacturers' answers to the key question posed during the interview, the predominant form under which a computer was sold for the purposes of our experimental index included the processor, both main and auxiliary memory, and other peripherals.

The validity of an index is inextricably connected to the type of price the index is supposed to measure. For the PPI program, the preferred price is defined as "the net revenue accruing to a specified producing establishment from a specified kind of buyer for [a] specified product shipped under specified transaction terms on a specified day of the month."[10] Emphasis is placed on the prices charged for items shipped in the same month, rather than "orders" or "futures" prices. Further, a distinction must be made between "list" or "book" prices and net transaction prices. The Bureau has always asked for net transaction prices, because it is felt they are a more realistic indication of what is really occurring in the marketplace: "BLS emphasizes . . . the need for reports of realistic transaction prices, including all discounts, premiums, rebates, allowances, etc., rather than fictitious list or book prices. The use of list prices in the industrial price program has been the exception, not the rule."[11] More specifically, even before the transition to the current industry-focused methodology of the PPI, a BLS survey concluded that approximately 20 percent of the traditional commodity indexes were based on list prices. Since that time (1978), the percentage most probably has declined due to more accurate reporting and a more concerted effort by BLS data collectors to collect the price of the net shipment.

We adhered strictly to the above methodology during both the pilot and experimental phases of our project. Not only did we request that all applicable discounts be reported in each measurement period, but we asked to whom the computer was sold (that is, the type of buyer). Discounts took many forms, including cash rebates and discounts on cumulative volume, quantity, and trade. Normally in the PPI program, we would use a probability selection technique that would identify a specific discount. Here, we asked for the company's normal price adjustments. In a small number of instances during the pilot study, we took more than one discount for the same product to see whether price adjustments moved differently. It has been suggested that a net transaction price is nothing more than a list price less a standard discount, implying that discounts move similarly in both magnitude and direction. In the small number of cases we investigated in the pilot study, there were instances where various discounts exhibited different magnitudes and moved in different directions. Examples of this phenomenon were in the areas of "original equipment manufacturer" (OEM), "value-added dealer" (VAD), and "value-added reseller" (VAR).

Experimental computer price index

Table 2 is an excerpt from the July 1990 *Producer Price Indexes* monthly detailed report.[12]

The experimental indexes in this report are treated separately from the traditional PPI commodity grouping system. Even though industry codes are provided that detail a published category, the indexes are wherever made, commodity based (similar commodity groupings without regard to the particular industries for which they are published). At present, the experimental series are excluded from the stage-of-processing indexes.

The experimental series are issued quarterly, with a base period of October 1988 = 100, as shown in the table. In *Producer Price Indexes*, they appear in table 13, which also provides year-to-year and quarter-to-quarter percent changes for these indexes. The indexes are not seasonally adjusted.

We decided on quarterly indexes for a number of reasons. The primary reason was more practical than empirical in nature: because the computer industry is a new industry on which the Bureau would be collecting price and product information, care would have to be taken to ensure that the frequency of repricing (or burden level) would be minimal relative to normal monthly pricing. We decided to collect lagged monthly prices for internal use, but publish indexes only four times a year. For example, if the quarter ending in October is our pricing period, we also ask for August and September prices. Our pricing date is the same as in the PPI, the Tuesday of the week that includes the 13th day of the month. We price as of the first month of the calendar quarter.

Secondly, results from the pilot study suggested to us that the incidence of price changes for computers occurred more on a quarterly, rather than a monthly, basis. If, after a designated period of time, we find the opposite to be true, and a change to monthly pricing does not burden our respondents, we will implement such a change. As a complicating factor, however, many of the price changes occurred on or just before major computer hardware and software trade shows, the most prominent of which are the Computer Distribution Expo (COMDEX) and the Federal Office Systems Expo (FOSE). Whether a causal connection exists between the two phenomena or whether their mutual occurrence is just random can only be answered by future observations made over a longer period of time.

Obviously, other market forces have an impact on price changes, and these changes may or may not coincide with our repricing quarters of January, April, July, and October. For example, during the first part of 1988, there was a shortage of dynamic random-access memory (DRAM) chips in the marketplace that was reflected in our pilot indexes. Depending on a particular manufacturer's inventory of these chips, prices declined more slowly, remained the same under the pressure of competition, or actually increased for a short period of time. By late 1988 the supply stabilized itself, and the disruptions are not reflected in our experimental index.

Another pricing phenomenon emerged in our pilot project in the 16-bit and 32-bit wordsize computer categories, and we assume that it is mirrored in the experimental index. When new microprocessor technology entered the market—for example, an 80386 replacing an 80286 chip or a 68030 replacing a 68020 chip—the price of the older technologies did not *at first* decline. One might have thought at a cursory glance that the price would have declined through market clearing. However, quite a different thing occurred: the price of the older model actually stabilized when that model was sold alongside the new model. Because our experimental index is a Laspeyres index designed to measure pure price change from items selected during the base period (from a fixed market basket), the new technology would not enter into our calculation, unless the old model were no longer manufactured or shipped. We thus expected the price of the older model to come down immediately upon introduction of the new model, contrary to what actually happened. One explanation of this phenomenon is that, even though the newer technology cost less, was faster, and provided more functionality than the older chip, the latter was still meeting customers' needs. There appeared to be a demand for the older processor, and manufacturers were still serving the niche created by that demand.

A good indication of how the computer industry is constantly changing is provided by an examination of the types and frequency of changes in components that have occurred in the experimental index for the past seven quarters. Table 3 summarizes these changes.

Table 3. **Frequency of changes in computer components, October 1988–July 1990**

[In percent]

Category of components, quality adjusted	Frequency of change
Hard-disk storage	31.9
Random-access memory	18.8
Clock speed	14.6
Warranty	6.8
Floppy disk storage	4.9
Tape drive	4.8
Number of users	4.2
Keyboard	3.5
Operating system	3.5
Port	3.5
Terminal	3.5

In almost all instances, the regression adjustment methodology was used for the first three categories: storage capacity, main memory, and clock speed (measured in megahertz for microprocessor-based computers and in millions of instructions per second (MIPS) for larger computers). Even though an attempt was made to acquire the resource cost information from the respondent for these functional changes, in more than 90 percent of the cases observed such information was not available for the first three categories of components. This is, however, to be expected, because the more sophisticated the item's functional change is, the more difficult it is to measure with traditional cost estimates. In other nonperformance areas, producer cost information was available on changes in such items as keyboards, terminals, and warranties.

Of the 170 computer models from 33 computer manufacturers that were originally tracked, we lost 31 models (18 percent of our original sample) and 6 manufacturers between October 1988 and July 1990. Overall, 144 different modifications with associated quality adjustments were made to items in the categories listed in table 3 as of the July 1990 quarter. This relatively high figure is a reflection of the many and frequent improvements that occur in this rapidly changing industry and indicates the time horizon necessary for reselecting a new market basket of products.

The regression model for each publication category was able to specify the functional changes for three performance categories—auxiliary storage, main memory, and clock speed—and was used predominantly in quality adjustment. In a number of instances, the manufacturer could give us an estimate of the packaged items, such as terminals, keyboards, and operating software upgrades, and we accepted these values for the resource cost adjustment approach. The categories of number of users and ports were used more as a marketing tool and were usually very low-cost, sometimes free, items. The flexibility of the composite quality adjustment methodology allowed us to use both implicit estimates of functional changes from regressions and resource cost estimates from the manufacturer for other changes if available.

Does the index mirror the industry?

Caution should be exercised in drawing conclusions from table 2, because the table reflects only seven quarters worth of data and uses a classification structure that is currently different from Census Bureau categories. In classifying computers, we attempted to avoid adjectives, applications, and dollar categories. As mentioned earlier, we debated at considerable length the question of how actually to publish the many different types of products included in the computer industry.

Competition among 16-bit and 32-bit wordsize computers with 8000, 80000, and 68000 series microprocessors has been fierce for a number of years. Competition still appears to be the driving force behind the declining indexes. With more powerful, faster chips in plentiful supply and the next generation of chips on the horizon, prices are expected to decline. Even the 3571–B23 category of "Other 32-bit wordsize computers," which encompasses the traditional midrange computers, has shown a modest price decline since October 1988. This category also includes what some refer to as minicomputers and competes with the high-end 32-bit workstation market. Moreover, the category 3571–C, of "Greater than 32-bit wordsize computers," or what others refer to as mainframe computers, has undergone a marked decline in price from the base-period price. In fact, all the declines we evidenced in our experimental index seem to mirror trade press reports. Whether this phenomenon will prevail in the future remains to be seen. For example, recent trade press reports suggest that manufacturers of personal computers are implementing programs to stabilize prices. As one source put it, "The days of bargain-basement PC prices may be over as the industry takes steps to end the price wars that marked 1989."[13] Of course, only time can substantiate that statement. However, based on the limited evidence presented in table 2, competition will still prevail.

Conclusion

All the declines we evidenced in our index seemed to mirror trade press reports.

From the outset, the goal of the experimental project was to demonstrate a feasible and supportable method for producing timely, ongoing, and maintainable price indexes for computer industry products. The most dramatic finding from the collection and repricing phase of the project was that the time horizon for many of the products included in this industry is extremely short relative to that of other industries repriced in the PPI. As previously mentioned, the normal resampling of industries for the PPI ranges from 5 to 7 years, depending on the complexity of the approximately 500 industries included in the index program. If we used this same time period as a reference for repricing for a major portion of the computer industry, it would include approximately two-and-one-half generations of computers, based on our study results!

Obviously, then, measuring price changes in a high-tech industry such as computers for the PPI program requires different collection, repricing, and quality adjustment procedures, as well as a different overall treatment of the data. The project went a long way toward dealing with these issues. Normal operational procedures have been modified, namely, by dedicating resources for resampling every 2 years, possibly by telephone, to expedite product selection. A data base for cross-sectional regression estimates must also be re-created for the same time period. This task will become easier as more data are entered into the modeling data base, ensuring the availability of timely, current data. All things considered, the expanding computer industry is far too important to be excluded from the PPI program. □

Footnotes

[1] For a more detailed explanation of the pilot indexes, see Brian C. Catron, "Price Measurement for Computer Hardware: A Demonstration of Quality Adjustment Techniques" (Bureau of Labor Statistics, Division of Industrial Prices and Price Indexes, Apr. 14, 1989, unpublished internal document).

[2] John F. Early and James H. Sinclair, "Quality Adjustment in the Producer Price Indexes," in Murray Foss, ed., *The U.S. National Income and Product Accounts*, vol. 47 (Washington, National Bureau of Economic Research, 1983), p. 109.

[3] Not all physical changes are treated as changes in quality. If a component does not perform its function better, it is not assumed to have undergone a change in quality. An example would be style changes in automobiles.

[4] See "Guidelines for Adjustment of New Automobile and Truck Prices for Changes in Quality of Product" (Bureau of Labor Statistics, 1980, rev., unpublished internal document). This document describes and defines the concepts and procedures used in adjusting quoted prices for quality change.

[5] *1987 Current Industrial Reports*, MA35R(87)-1 (U.S. Department of Commerce, Bureau of the Census, August 1988), p. 2.

[6] This company, located in Lexington, MA, provided a computer tape that identified a large number of manufacturers, prices, and products in the microcomputer industry that were used for modeling.

[7] See Office of Management and Budget, *Standard Industrial Classification Manual, 1987* (Washington, U.S. Government Printing Office), p. 215.

[8] "Computers and Office and Accounting Machines," *Current Industrial Reports*, MA35R(87)-1 (Bureau of the Census, August 1987).

[9] Peter L. Burris, ed., *The Grey Sheet, Computer Industry Report*, vol. 24, nos. 17–18 (International Data Corporation, 1989).

[10] See chapter on "Producer Prices," in *BLS Handbook of Methods*, Bulletin 2285 (Bureau of Labor Statistics, 1988), p. 126.

[11] *BLS Handbook*, p. 126.

[12] Excerpt from *Producer Price Indexes, Data for July 1990* (Bureau of Labor Statistics, 1990), p. 199.

[13] See "Industry Leaders Put Brakes on PC Discounting," *PC World*, Mar. 5, 1990, p. 1.

A note on communications

The *Monthly Labor Review* welcomes communications that supplement, challenge, or expand on research published in its pages. To be considered for publication, communications should be factual and analytical, not polemical in tone. Communications should be addressed to the Editor-in-Chief, *Monthly Labor Review*, Bureau of Labor Statistics, U.S. Department of Labor, Washington, DC 20212