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AUDITING THE PRODUCER PRICE INDEX: MICRO EVIDENCE FROM PRESCRIPTION PHARMACEUTICAL PREPARATIONS

Ernst R. Berndt

Zvi Griliches

Joshua G. Rosett

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Cambridge, MA 02138
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ABSTRACT

In this paper we focus on a mystery we uncovered while undertaking a detailed audit of the US Bureau of Labor Statistics producer price index (PPI). We summarize our puzzle as follows. From January 1984 through December 1989, the BLS price index for SIC 28341 (prescription pharmaceutical preparations) grew at an annual rate of 9.09%. For purposes of comparison, we have obtained monthly price and quantity sales data on all prescription pharmaceutical preparation products sold by four major US pharmaceutical manufacturers, accounting for about 24% of total industry domestic sales in 1989. Using Laspeyres price index construction procedures on these data that mimic BLS methods, we find that over the same time period, the four-company price index increased at only 6.68% per year. Finally, when we employ a Divisia price index procedure with smoothed weights that incorporates new goods immediately, the aggregate price index for these four firms grows at a rate of only 6.03% per year.

Why is it that the official BLS price index grows approximately 50% more rapidly (9.09% vs. 6.03%) than the Divisia price index? That mystery is the focal point of our paper.

Ernst R. Berndt
NBER
1050 Massachusetts Avenue
Cambridge, MA 02138
and M.I.T.

Zvi Griliches
NBER
1050 Massachusetts Avenue
Cambridge, MA 02138
and Harvard University

Joshua G. Rosett
Department of Accountancy
University of Illinois
1206 South Sixth Street
Champaign, IL 61820
and NBER

AUDITING THE PRODUCER PRICE INDEX:

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"All index numbers which are not freakish or biased practically agree with each other."

Irving Fisher[1]

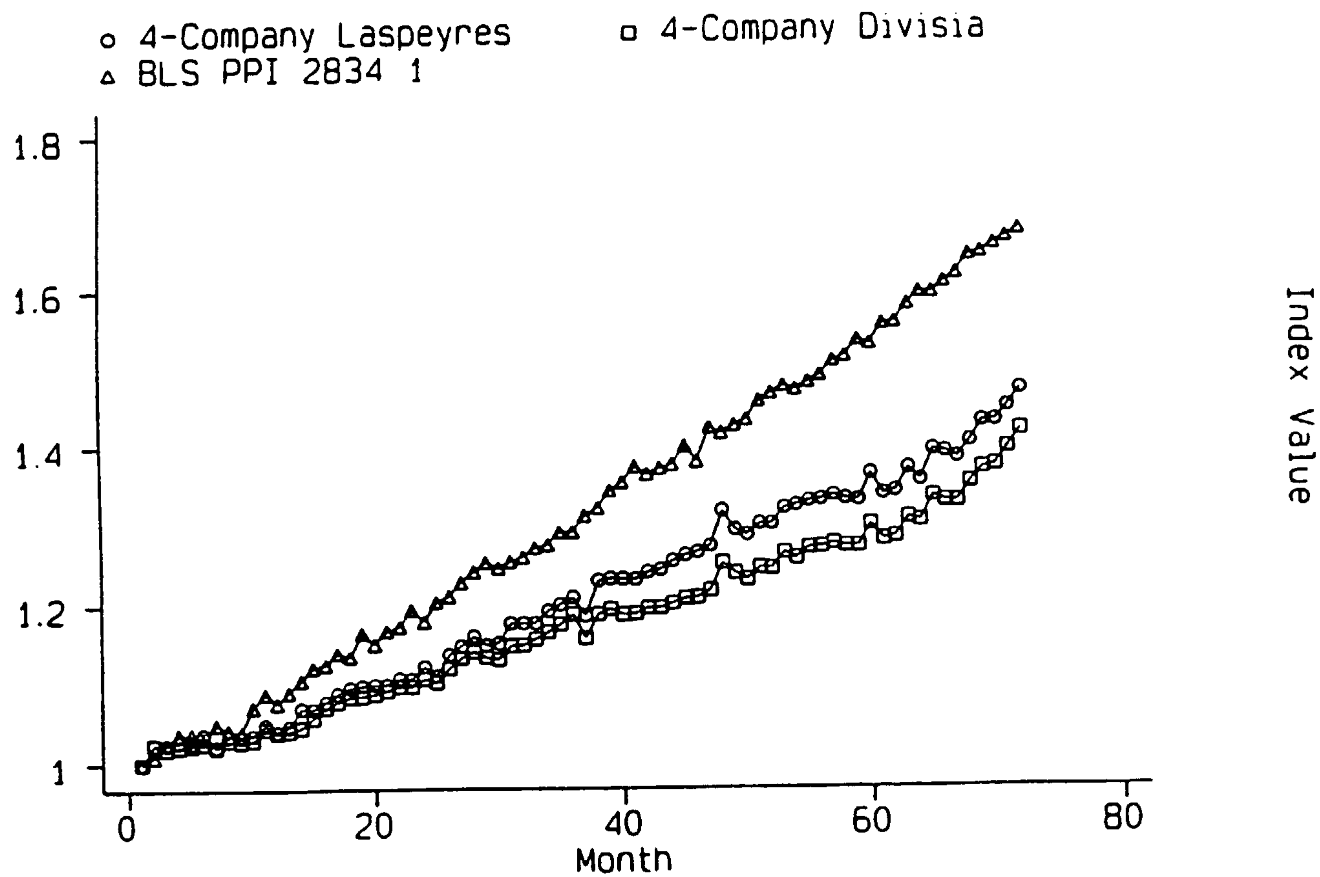
I. INTRODUCTION

In this paper we focus on a mystery we uncovered while undertaking a detailed audit of the US Bureau of Labor Statistics producer price index (PPI). Our puzzle is summarized in Figure 1 below. From January 1984 through December 1989, the BLS price index for SIC 28341 (prescription pharmaceutical prepartions) grew at an annual rate of 9.09%. For purposes of comparison, we have obtained monthly price and quantity sales data on all 2,090 prescription pharmaceutical preparation products sold by four major pharmaceutical manufac-

[Insert Figure 1 Near Here]

turers in the US, accounting for about 24% of total domestic industry sales in 1989. Using BLS-type Laspeyres price index construction procedures on these data with spliced fixed weights,[2] we find that over the same time period, the four-company price index increased at only 6.68% per year. Finally, when we employ a Divisia price index procedure that incorporates new goods immediately, the aggregate four-firm price index grows at a rate of only 6.03% per year. Why is it that the BLS price index grows approximately 50% more rapidly (9.09% vs. 6.03%) than the Divisia price index? This mystery is the focal point of our paper.[3]

A number of factors could account for the difference. First, our four firms could be unrepresentative of the industry as a whole. Second, the products and firms sampled by the BLS could be unrepresentative of industry transactions. This sampling discrepancy could reflect the fact that



4-Company Laspeyres
BLS PPI 2834 1
4-Company Divisia
1.8
1.6
1.4
1.2
1
0
20
40
60
80
Month
Index Value

FIG. 1

participation by firms in providing BLS price data is voluntary. Also, sampling procedures used by the BLS might not capture adequately the price trends of new products, particularly in industries characterized by rapid technological change. Third, the prices reported by the firms to the BLS might differ from the firms' actual average transactions prices.[4] Fourth, use of fixed weight price indexes such as the Laspeyres might result in rather different growth rates from those based on chained procedures such as the Divisia index. Note that one would not expect unmeasured quality changes to account for the difference, since none of the three indexes reported above connects generics to their patented antecedents, nor does any compare "improved" drugs to their predecessors and adjust the price index accordingly using, for example, hedonic methods.

Our interest in the reliability of official producer price indexes stems from a more general research interest in the measurement of output and productivity growth. Given the essential identity between value of sales and a price index times a quantity index, any errors in the PPI have important implications for the accuracy of measured rates of inflation, real output changes, real investment, and growth in productivity.

To begin assessing the reliability of the PPI, we decided to audit one industry in detail. Our choice of the pharmaceutical preparations industry was affected by the fact that this industry is one in which technological change is significant, its pricing of products has been the focus of considerable public attention, it has other attributes of interest to us (for example, it is heavily engaged in research and development), and, on a practical basis, arrangements could be made to have proprietary micro data made available for analysis. It is worth noting that our analysis is confined to the PPI for this industry, and we do not examine issues involving the Consumer Price Index (CPI), for which a sample of prescription pharmaceutical prices drawn at the retail and hospital levels would be required. However, some of the important issues involving the treatment of generics and new goods may be similar for the PPI and CPI.

We start our paper in Section II with a brief overview of the PPI; a more detailed discussion is found in Appendix A to this paper.[5] In Section III we provide a summary of the four anonymous pharmaceutical manufacturers, comment on another source of data (IMS America) that, for one significant sub-class of pharmaceutical preparations (systemic anti-infectives), encompasses almost the entire universe of products sold domestically, and present some preliminary empirical findings involving data comparisons. The principal results of our empirical analysis are presented in Section IV, and there we report on our various attempts to unravel this mystery. In Section V we address the "youthful goods" problem in further detail. Finally, in Section VI we summarize our findings and describe our agenda for further research.

II. THE BLS PRODUCER PRICE INDEX FOR SIC 28341

The PPI is one of the oldest continuous statistical data systems published by the BLS, although until 1978 it was known as the Wholesale Price Index (WPI). The first WPI, published for the base period 1890-1899, was an unweighted average of price relatives for about 250 commodities. Since that time, many changes have been made, including alterations in the sample of commodities, the base period, and the method of calculating the index. According to the U.S. Department of Labor [1988, p. 125], the 1978 name change from WPI to PPI "...was intended to reemphasize that the industrial price program continues to be based on prices received by producers from whoever makes the first purchase, rather than on prices paid to wholesalers by retailers or others further removed in the distribution chain." Currently the PPI program at BLS encompasses the construction of aggregate price indexes for almost 500 mining and manufacturing industries, including approximately 8,000 indexes for specific product categories, based on reports from approximately 23,000 responding companies.

The BLS computes and publishes an overall price index for pharmaceutical preparations (Standard Industrial Classification [SIC] code 2834), for prescription pharmaceuticals (SIC 28341), and for roughly 50 sub-groups from the seven to nine-digit SIC level; a complete list of product classes reported by the BLS in SIC 28341 is given in Table 1 below.[6]

Table 1

Industries in SIC 28341 for which the BLS Publishes Monthly Price Indexes 1984-89

Industry	SIC Code	Industry (continued)	SIC Code
Pharmaceutical Preparations	2834	CNS stimulants	2834 123
Pharmaceutical preparations, prescriptions	2834 1	Contraceptives	2834 124
Analgesics	2834 102	Cough & cold preparations	2834 125
Narcotics analgesics	2834 1021	Nasal decongestants	2834 12512
Codeine and Combinations	2834 10211	Dermatological preparations	2834 126
Non-narcotic analgesics	2834 1022	Acne preparations	2834 12611
Aspirin, APC & related	2834 10229	Fungicides	2834 12619
Antiarthritics	2834 105	Topic antiinfectives	2834 12631
Anticoagulants	2834 106	Antipruritics	2834 12641
Anticonvulsants	2834 107	Diabetes therapy	2834 127
Systemic antihistamines	2834 109	Diuretics	2834 128
Systemic antiinfectives	2834 111	Hormones	2834 135
Broad and medium spectrum antibiotics	2834 1111	Hospital solutions	2834 136
Cephalosoporins	2834 11111	I.V. solutions 50 ml and under	2834 13604
Broad spectrum penicillins	2834 11112	Muscle relaxants	2834 139
Erythromycins	2834 11113	Nutrients and supplements	2834 141
Tetracyclines	2834 11114	Opthalmic and otic preparations	2834 142
Other broad and medium spectrum antibiotics	2834 11119	Psychotherapeutics	2834 144
Systemic penicillins	2834 11129	Tranquilizers	2834 1441
Urinary antibacterials	2834 11139	Major tranquilizers	2834 14411
Antispasmodic/antisecretory	2834 116	Minor tranquilizers	2834 14412
Bronchial therapy	2834 118	Antidepressants	2834 1442
Cancer therapy products	2834 119	Sedatives	2834 145
Cardiovascular therapy	2834 121	Vitamins	2834 148
Antihypertensive drugs	2834 12119	Multivitamins	2834 14819
Vasodilators	2834 12129	Miscellaneous prescription pharmaceutical preparations	2834 198
Other cardiovasculars	2834 12191		

The PPI for the various pharamaceutial products are based on prices for a fixed basket of products, drawn from monthly voluntary reporting to the BLS by selected manufacturing establishments. Several points are worth noting.

First, the fixed basket of products is chosen through a sampling procedure implemented at irregular intervals across industries, whose frequency depends in part on the perceived stability of the industry. Detailed surveys of pharmaceutical firms were conducted in 1980 and in 1987, and the fixed baskets were changed in 1981 and in January 1988; the BLS refers to the 1980 survey as "Cycle I", and that from 1987 as "Cycle II".

Second, in principle, the sample is drawn from the universe of all products from domestic establishments whose main production is in SIC 2834.[7] A BLS field representative visits selected establishments (in the pharmaceutical industry, the BLS visits wherever the appropriate records are kept, usually company headquarters) during the survey year, and uses a procedure called "disaggregation" to settle on which detailed products are to be sampled. Once this initial visit is completed, subsequent "repricing" for the selected commodities occurs on a monthly basis, typically by the respondent company filling out and returning forms sent it by mail by the BLS; these forms are pre-printed with the detailed description of the chosen products, the reported prices over the previous three or four months, and a request for a price quote from the Tuesday of the week containing the 13th of the month. Currently, approximately 50 responding companies in SIC 28341 provide about 400 individual price quotations.

Third, once monthly data are in hand, the BLS calculates the PPI according to a modified Laspeyres formula, details of which are given in Appendix A.

Fourth, during the disaggregation process, products are defined in very specific detail. As the U. S. Department of Labor [1986a, 1989] manuals emphasize, any price-determining characteristic distinguishes one product from another. The U. S. Department of Labor [1988, p. 126] summarizes price-determining characteristics as follows:

> "If a company charges more for a red widget than a white one, color is one of the price-determining variables; if all widgets sell for the same price regardless of color, color is not a price-determining variable."

In the pharmaceutical context, if prices of bottles differ, a bottle of 100 pills each having 50 milligrams of a drug is not the same as a bottle of 50 pills of 100 milligrams, even though both bottles contain 5,000 milligrams of the same drug. Moreover, transaction-specific factors such as volume discounts or freight costs (if absorbed by the manufacturer) affect price, so these factors are included in the definition of the product.

Sixth, precisely how the BLS determines the total number of price quotations assigned to each establishment is not completely clear, but apparently this decision involves substantial judgment. According to the US Department of Labor [1986b, pp. 42-46], the number of quotes taken from an establishment depends on industry concentration, price variations within and across establishments, establishment size, and the number of products produced at each establishment. Moreover, discussions with BLS personnel suggest that for any sampled establishment in any industry, there is a minimum of two quotes and a maximum of sixteen. In recent years, the number of companies sampled has declined within the pharmaceutical industry, there has been an effort to increase quotes to large sample units and to distribute quotes across product lines to create more efficient index estimates. Hence, in practice the choice of products sampled departs significantly from strict probability sampling procedures.

Finally, although the BLS manuals emphasize that transactions rather than list prices are desired, and Form 473P states clearly that "net transactions prices are the most desirable type of price," the BLS also accepts net list prices (with additional pricing terms listed separately, such as discounts for prompt payment), or other estimates of prices. Despite the BLS emphasis on transactions prices, our discussions with personnel at various pharmaceutical firms suggest that firms typically interpret this request as being one for net list rather than net transactions prices.

For our purposes it is important to note that once detailed products have been chosen by the disaggregation process, the BLS obtains a time-series of prices for highly defined products which stays constant over fairly long intervals -- indeed, the six years between re-sampling suggests that the set of sampled commodities is dominated by mature, rather than innovative products.

As was noted earlier, the most recent detailed survey in pharmaceuticals occurred in mid-1987, and beginning in December 1987, the PPI was revised to reflect the new sample of products, within-cell weights, and between-cell weights from the 1982 Census of Manufacturers. Currently, PPI's for pharmaceutical products are based at 100 in June 1981.

Although in principle the PPI has been based on probability sampling since late 1978, in practice it is clear that a number of departures from ideal establishment selection and disaggregation occur. In addition to the judgmental manner in which the number of price quotes per establishment is determined, the voluntary nature of the PPI introduces problems for BLS field representatives. Moreover, the U. S. Department of Labor [1986a,1989] data collection manuals provide extensive advice to BLS field representatives when the establishment employee interviewed by BLS personnel may not have or may refuse to provide sufficient information for complete disaggregation. Of course, the implications of such departures of practice from theory are not clear.

III. DATA SETS USED IN THIS STUDY AND INITIAL EMPIRICAL FINDINGS

We now move on to a discussion of the various data sets used in our analysis. Confidential data have been provided us by four of the ten largest firms in the industry, together comprising about 24% of domestic sales in 1989. For each of the 2,090 prescription pharmaceutical products produced by these four companies, we have been supplied monthly data from January 1984 through December 1989 (72 monthly observations) on net revenues, quantity shipped, net revenue/quantity, and product identifiers. Net revenues are close to accrual basis, implying that the computed average transactions prices are close to the true quantity-weighted average prices for sales in the given month. However, it is worth noting that such average transactions prices could in principle be affected by the size and location of transactions, and that no information is available to us on whether such features of transactions have changed over time. The product identifiers allow unchanged products (down to the presentation level) to be followed over time, since presentation characteristics such as form (vial, capsule), dosage, package size (count) and type (bottle, blister pack) are known.

Since none of the companies had complete records of forms it had filled out for the BLS, in response to written requests from the individual companies, the BLS provided a computer data file to each company containing records of price quotes reported by that company to the BLS from January 1984 through December 1989. The companies then supplied these files to us. The sample frame items selected by the BLS represented roughly 10-11% of the four companies' total revenues in both cycles.

Additional product details were provided us by each company, and these were used to classify products into therapeutic classes as defined by the BLS. Of the 2,551 products supplied overall, we succeeded in classifying 81.9% of them into specific BLS prescription cell groups (see Table 1 for a list of these cells); these successfully classified products accounted for more than 98% of revenues over the sample period.[8] In this paper, when we present price index data, we refer to calculations based on the 2,090 classified prescription products only.

New products are of particular interest, for they may embody technological innovations which allow therapeutic actions for which there is no known price, and the speed with which these new products are introduced into price index calculations can substantially affect the measured overall rate of price growth. Many of the new products in the companies' data sets are actually modifications of existing product lines (new packaging, etc.), but other products are truly new in the sense of being the first presentation of a newly approved drug. We have also examined products that exit. The extremely small revenue share of exiting products makes it improbable for them to have a substantial impact on aggregate measures of price, and therefore we do not explore exits in detail in this study.

It is of course quite possible that, within therapeutic classes, our 4-company sample of firms is unrepresentative of the industry as a whole. To assess this issue for one important class of drugs, we have obtained monthly price and revenue data on almost the entire universe of products within systemic anti-infectives (SIC 2834-111), a sub-class accounting for approximately 16% of SIC 28341 domestic total sales in 1987. The data were purchased from IMS America.[9] The number of products for which IMS monthly price data is available is 5,545, but the IMS time period differs slightly from that for our four companies -- from October 1984 rather than January 1984 to December 1989.

There are several other important differences between the company-specific and IMS data.[10] While the data underlying the PPI are those on prices received by producers from whomever makes the first purchase, the IMS data cover transactions at a different point in the distribution chain. Specifically, the IMS data represent the purchases made by hospitals and by retailers of ethical, ethical over-the-counter, and proprietary pharmaceutical products. IMS estimates that its drugstore audit covers 67% of the US pharmaceutical market, and that its hospital audit covers an additional 16%. The market segments that the two audits do not monitor include foodstores, dispensing physicians, HMO's, mail order nursing homes, and clinics.

The purchase information obtained by IMS from a panel of hospitals and a sample of wholesale warehouses for its hospital audit is projected by IMS to national (continental US) levels, not including federal hospitals or nursing homes. Based on invoice data, the prices reflect the actual costs of products to hospitals, whether purchased from a manufacturer or a wholesaler.[11]

In the retail data set, invoice-based price data reflect the actual cost to retailers for the ethical, ethical over-the-counter and proprietary pharmaceutical products, whether purchased from a manufacturer or a wholesaler (IMS notes that 92% of total pharmaceuticals purchased by retail outlets are from wholesalers). For both the hospital and retail data, IMS cautions that prompt payment cash discounts (usually 2% off) and bottomline invoice discounts are not reflected in the dollar purchase amounts.

III.a PRICE INDEXES DISAGGREGATED BY PRODUCT CLASS

Because the PPI and IMS data are taken from different points in the distribution chain, the prices (unit costs) in the IMS data reflect markups over the prices reported by producers to the BLS. These markups could vary over time, or be trended. To check on the possibility that IMS prices grow differently from producer prices, we have compared prices for 241 exact product matches between IMS and the four-company data.[12] Specifically, for each of these 241 products, we have taken the ratio of the IMS unit cost to the company's average revenue, monthly from October 1984 through December 1990. We then computed a Divisia index of this ratio, using company revenue weights. If the markups were constant over time, growth of this Divisia index would be zero. Over the October 1984-December 1990 time period, this index grew from 1.000 to 1.041, an average annual growth rate (AAGR) of 0.77%, implying that IMS prices grew slightly more than company-specific average revenues for these 241 products.[13] We interpret this result as implying that even though IMS and PPI prices are drawn from different points in the distribution chain, on average their price changes are similar over the sample time period. This similarity in overall growth rates of the IMS and company-provided data also gives us some confidence in using the IMS data as a proxy for producer price level price index calculations.[14]

Using this IMS data, we have computed alternative price indexes for the systemic anti-infectives sub-class (recall that the IMS data encompass almost the universe of products sold domestically). Our results are summarized in Figure 2. Over the October 1984 through December 1989 time period, while the

(Insert Figure 2 somewhere near here)

official BLS PPI for systemic anti-infectives increased at an AAGR of 6.26%, the IMS Laspeyres fixed-weight index grew at 2.63%, and the IMS Divisia index with new goods included immediately grew at only 1.54% -- one fourth the growth rate of the official PPI.[15] Hence, there is indeed a mystery here, for when data are taken from a product class with almost universal coverage, the official PPI and the IMS-based Laspeyres and Divisia indexes grow at very different rates. Hence it appears that our initial findings based on all products from but four firms are corroborated using the universe of products for the systemic anti-infective subclass.

Some other evidence can shed light on the representativeness of our four-company sample and, in particular on the possibility that product mix differentials along with variations in price growth by product sub-class could

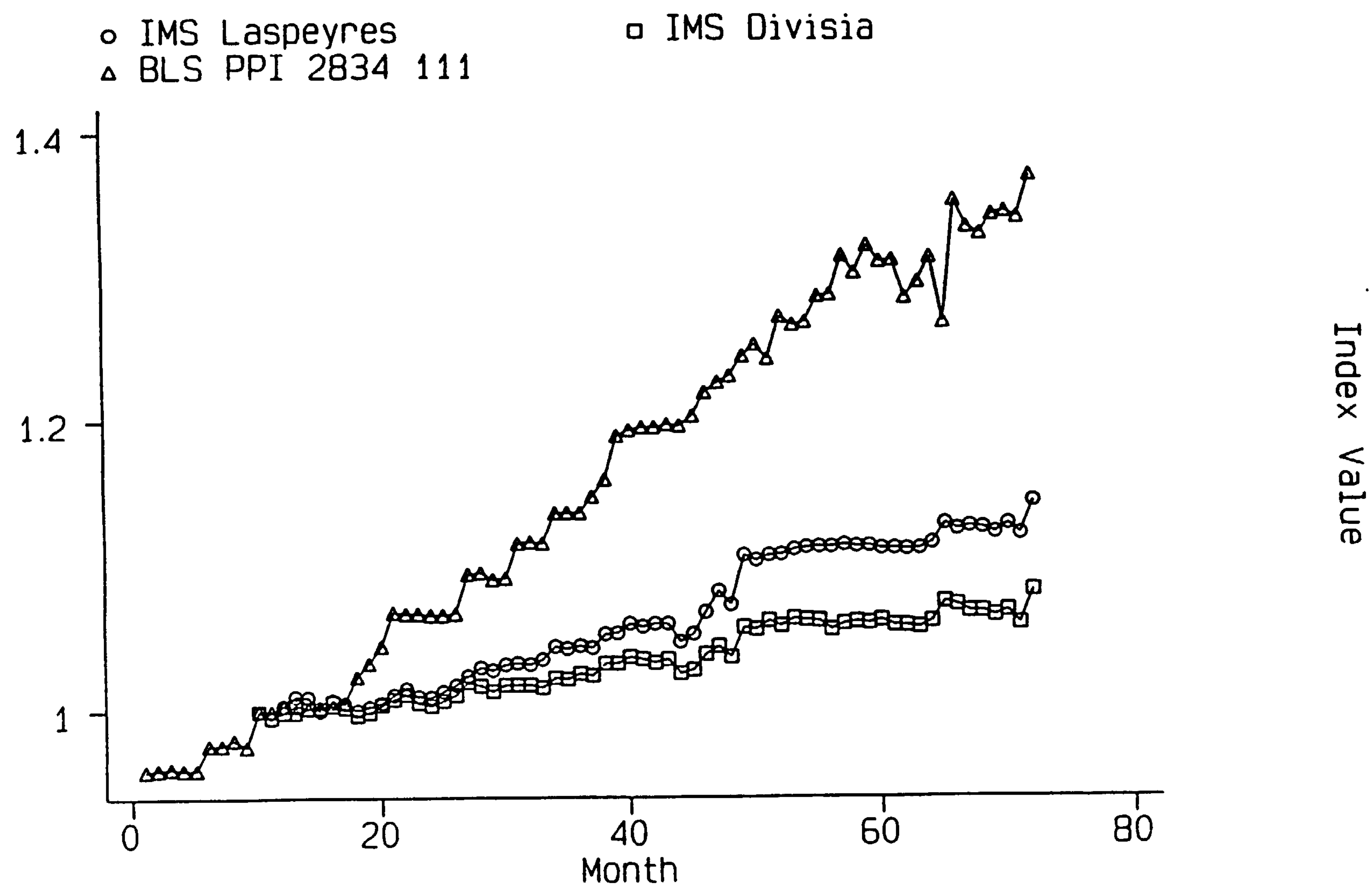

IMS Laspeyres
BLS PPI 2834 111
IMS Divisia
1.4
1.2
1
0
20
40
60
80
Month
Index Value

FIG. 2

Table 2

FOUR COMPANY AND INDUSTRY DATA

Product Class Name	Product Class Number	Product Share Distribution 4-Company 1987	Product Share Distribution IMS-All 1987	Census-BLS Relative Weights 1977	Census-BLS Relative Weights 1982	Approximate Four-Company Concentration Ratio 1987
Analgesics	102	3.59%	7.22%	5.21%	9.82%	12.01%
Anti-arthritics	105	13.36	6.21	3.41	4.83	51.92
Anti-coagulants	106	0.14	0.59	0.51	0.68	5.84
Systemic Anti-infectives	111	26.46	15.59	14.23	15.28	40.99
Anti-spasmodic/ Anti-secretory	116	1.30	7.46	1.70	1.01	4.21
Cancer therapy	119	0.65	2.94	1.12	3.77	5.32
Cardiovascular	121	17.44	19.60	10.26	15.64	21.49
Cough & Cold Preparations	125	0.02	1.67	2.04	3.60	0.32
Dermatological Preparations	126	0.56	3.48	2.60	3.37	3.86
Diabetes Therapy	127	9.34	2.89	2.49	1.97	78.08
Hormones	135	2.56	4.50	10.92	3.78	13.75
Muscle Relaxants	139	1.83	1.79	1.71	0.86	24.66
Nutrients & Supplements	141	0.08	2.30	0.23	0.24	0.81
Psychotherapeutics	144	9.05	8.27	10.95	7.57	26.43
Sedatives	145	2.76	1.10	1.18	0.80	60.91
All Others		10.86	14.39	31.44	26.78	
TOTAL		100.00	100.00	100.00	100.00	24.16

Notes: The 4-company product share distribution is total revenues for the four companies by product class, divided by the sum of the four companies' total prescription classified revenues (total 1987 revenue less non-prescription assignments less unassigned revenues). The IMS-All product share distribution is total industry revenues by product class divided by the sum of total revenues across all firms in the industry. The Census-BLS weights are the relative value of shipments net of intraindustry sales by product class, based on the 1977 and 1982 Census. The 4-company concentration ratio is company-provided data on total revenues for the four firms in this study by product class, divided by IMS estimated total industry revenues by product class. Since the IMS data include wholesaler markups, this 4-company concentration ratio slightly understates the true ratio.

account for differences in four-company price growth vs. that of the official PPI. Based on revenue data from the four-company sample, we have computed product revenue share data by product class, and compared these to industry-wide product distribution data estimated by IMS.[16] The two sets of product distribution shares are given in Table 2. There it is seen that product distribution shares differ somewhat between our four-company sample and the IMS "universe".

We have also obtained Census Bureau data on revenues by product class based on the 1977 and 1982 Census of Manufactures. As is seen in Table 2, the 1982 Census-BLS weights are broadly consistent with the product share data reported by IMS for 1987, although by 1987 the weights of anti-spasmodic/anti-secretory, cardiovascular, and nutrients & supplements were larger than in 1982, while that for analgesics was somewhat smaller.

In Table 3, we report AAGR of the published PPI, the four-company Laspeyres, and the four-company Divisia index, by product class, over the 1/84 - 12/89 time period. The Laspeyres index mimicks the BLS fixed weight with splice computational procedures, whereas the Divisia index includes new goods immediately and employs smoothed four-month moving average share weights.[17] As is seen in Table 3, in most cases the PPI growth is larger than that for the four-company Divisia (especially for cancer therapy products, dermatological preparations, and sedatives), but in some cases the PPI grows less rapidly than the four-company Divisia (for example, in anti-arthritics, and especially in muscle relaxants). We conclude, therefore, that while on average the PPI for pharmaceutical preparations grows considerably more rapidly than the four-company Divisia (9.09% vs. 6.03%), there is considerable diversity across sub-classes and in some cases the inequality is reversed.

Table 3

GROWTH IN ALTERNATIVE PRICE INDEXES BY DISAGGREGATED PRODUCT CLASS

Product Class Name	Product Class No.	AAGR of Price Indexes 1/84 thru 12/89 Official PPI SIC 28341	4-Company Laspeyres	4-Company Divisia
Analgesics	102	12.67%	9.55%	8.63%
Anti-arthritics	105	1.92	5.52	5.68
Anti-coagulants	106	na	1.59	4.50
Systemic Anti-infectives	111	6.22	2.21	1.20
Anti-spasmodic/ Anti-secretory	116	na	3.01	5.51
Cancer therapy	119	12.66	-2.01	-0.17
Cardiovascular	121	10.49	10.54	8.16
Cough & Cold Preparations	125	8.75	7.24	7.15
Dermatological Preparations	126	12.76	6.53	5.80
Diabetes Therapy	127	na	4.64	3.99
Hormones	135	5.12	4.31	2.24
Muscle Relaxants	139	10.92	12.96	22.63
Nutrients & Supplements	141	8.75	4.77	4.59
Psychotherapeutics	144	14.04	13.02	9.76
Sedatives	145	18.59	13.43	9.33
TOTAL		9.09	6.68	6.03
Total Using 1977 Census Weights			7.06	5.81
Total Using 1982 Census Weights			6.97	5.87

Note: na implies that the PPI for this industry is not published, due to an insufficient number of reportings to the BLS.

As another check on the persistence of our mystery and the representativeness of our four-firm sample, we have used item-specific weights to compute AAGR by industry sub-class (see the last two columns of Table 3), but have then constructed an overall price index weighting these sub-classes using the BLS-Census weights from Table 2, rather than the four-company weights. If the revenue distribution across product classes in our four companies were sufficiently different from the BLS-Census weights, then the AAGR for SIC 28341 in total could differ depending on what weights were employed. As is seen in the last three rows of Table 3, however, this is not the case. Using four-company sub-class weights, we see that the AAGR of the Laspeyres index is 6.68%, while those based on the 1977 and 1982 Census weights are 7.06% and 6.97%, respectively; for the Divisia index, the four-company weights yield an AAGR of 6.03%, while use of the 1977 or 1982 Census weights generates AAGR's of 5.81% and 5.87%. Since these differences are minor compared to the much larger AAGR of the official PPI (9.09%), we conclude that variations in revenue product class weights between our four companies and the industry overall cannot account for the discrepancy between growth of the official PPI and various price indexes based on our four-company data.

III.b REPORTED VS. ACTUAL AVERAGE TRANSACTIONS PRICES

As another aspect of our data, we have compared prices reported to the BLS by the four companies with average transactions prices received by the company. For the 25 products sampled in Cycle I and for the 46 items sampled in Cycle II from the four companies (7 are retained from Cycle I to Cycle II, leaving a total of 64 products) the Laspeyres index of prices reported to the BLS increased at an AAGR of 8.94%, while average transactions prices increased at 9.52% per year.[18] Thus the 8.94% AAGR of prices reported to the BLS by our four companies is almost identical to the 9.09% AAGR of the PPI, suggesting that in terms of price growth for sampled items, our four companies are essentially representative of the industry as a whole.

We have also compared reported prices and average transactions prices for the sampled items in the systemic anti-infectives product sub-class. Over the entire 1/84-12/89 time span the two Laspeyres indexes grew at virtually identical rates -- 8.60% for transactions prices, and 8.53% for reported prices, both of which are considerably larger than the official PPI which grew at an AAGR of 6.22%.[19]

Reported and average transactions prices can also be compared in terms of levels rather than growth rates. For the same four-company sample, the unweighted average of the ratio of reported to average transaction price was 1.090, while a corresponding revenue-weighted ratio is 1.032; it is worth noting, however, that these ratios display considerable variability.

IV. SOME CLUES AND AN IMPORTANT FINDING

Our analysis to this point suggests that the products sampled by the BLS in this industry appear to have price trends that differ from representative transactions for the four companies in our sample, and in the systemic anti-infective sub-class, from essentially the industry as a whole. What is it about the BLS sampling procedures that on average appear to miss the smaller price increases of representative transactions?

Since the potential existence of a "new goods" problem has been known for quite some time,[20] we began our search for an explanation by simply looking at the mean age of products sampled by the BLS relative to the average age of all dated products in the four companies.[21] This coarse analysis turned out to be uninformative, since differences were small.

Another line we pursued, following a conjecture presented in Berndt, Griliches and Rosett [1990], involved examining the extent to which items sampled by the BLS in Cycle I were re-sampled by them in Cycle II. For the 25 items in the four companies sampled by the BLS in Cycle I, seven were re-sampled in Cycle II. Whether such a 28% re-sampling rate is consistent with probability sampling procedures is not clear, but it appears unlikely to us that this amount of re-sampling could be responsible for the BLS sample failing to pick up adequately the smaller price increases of representative transactions.

We then examined the role of new products in a different manner, conjecturing that while the distribution of products by age may on average be roughly similar for the BLS sampled items and the four-company aggregate, they might be skewed in different ways. To follow this up, we first defined six age groups (less than two years old, between 2 and 3.999 years, 4 and 6.999 years, 7 and 9.999 years, 10 and 24.999 years, and 25 or more years old). We then divide age group specific revenues of BLS sampled items in the four companies by total annual revenues for all BLS sampled items at the four companies. Similarly, four-company age-specific revenue shares were defined as the aggregate annual age-group specific revenues for the four companies divided by total annual revenues for the four companies. As is seen in Table 4, the results of these calculations begin to provide important clues to help unravel our mystery.

Table 4

Annual Revenue Shares by Age of Product for Items at the Four Companies Sampled by the BLS, and for All Products at the Four Companies

	CYCLE I TIME PERIOD				CYCLE II TIME PERIOD			
Age in Years	Universe 1984	Sample 1984	Universe 1987	Sample 1987	Universe 1988	Sample 1988	Universe 1989	Sample 1989
0 - 1.999	20.78%	0.00%	32.57%	0.00%	21.85%	8.58%	28.29%	7.32%
2 - 3.999	16.70	8.96	14.81	9.08	8.62	4.02	7.16	3.28
4 - 6.999	17.40	13.13	20.94	29.99	29.13	33.20	28.11	33.39
7 - 9.999	11.73	30.24	10.01	28.72	18.79	39.19	19.14	44.56
10 - 24.999	23.43	45.18	15.92	30.21	16.92	13.32	13.43	10.05
25 or more	9.96	2.50	5.75	2.00	4.69	1.69	3.87	1.41
TOTAL	100.00	100.01	100.00	100.00	100.00	100.00	100.00	100.01

Notes: The age in years for Cycle I is as of January 1, 1984, and that for Cycle II is January 1, 1988. Totals may not sum to 100% due to rounding.

In 1984 and 1987, while items under two years of age were not sampled at all by the BLS (recall that the Cycle I survey occured in June 1981), products less than two years comprised about 21% (1984) to 33% (1987) of total sales at the four companies; products between two and four years old comprised about 17% (1984) or 15% (1987) of company total sales, while BLS sampled items within this age group constituted about 9% of revenues in both 1984 and 1987. Altogether for both age groups, shares of BLS sampled products under four years of age generated only 9% of revenues, while at the four companies these products constituted between 38% (1984) and 47% (1987) of total sales. Hence, younger products appear to be undersampled by the BLS.

Relative to company-wide shares, during both cycles the BLS over-sampled medium-aged products, especially in the 7-10 age group. For example, as is seen in Table 4, BLS sampled products between 7 and 10 years of age accounted for about 30% of 1984 BLS item revenues, but this age group generated only 12% of total company revenues; in 1989, the corresponding shares are 45% and 19%.

Recall that earlier we reported that sales-weighted mean ages for BLS sampled items and the universe of the four-company items were very similar. In this context, it is worth noting that the age distribution of products sampled by the BLS tends to be much more concentrated than is that for all products at the four companies. In 1989, for example, products between ages 4 and 10 comprised about 78% of BLS sampled item revenues, yet only accounted for about 47% of four-company revenues.

While these substantial differences in shares by age group are striking, they would not contribute at all to unravelling our mystery were it the case that product price changes by age group are similar. If, however, for whatever reason, younger products that are undersampled by the BLS experience less than average price increases while medium-aged, oversampled items undergo larger price increases, then we would be able to understand better why the AAGR of the four-company universe and the PPI differ.

To check on this further, we ran a regression based on 5,761 observations from our four-company sample. Specifically, we first computed an annual average transactions price for each product as total annual revenues divided by total annual quantity. We then defined an annual price change dependent variable d log P as the logarithmic first differences of these prices. As regressors, we specified dummy variables for the age of the product for the six age classes noted above (using the age of the product as of December 31 of the latter year), company dummies, year dummies, and SIC product class dummies. The results of this regression, with observations weighted by revenue shares[22], are presented in Table 5. Note that the year dummies refer to differences in the rate of change from that occurring between 1984 and 1985; the age dummies are interpreted as differences in the rate of price growth from that for the over age 25 product group.

As is seen in Column (1) of Table 5, relative to the over age 25 product group, items less than two years old experience about a 3.5% smaller annual price change, while items between 7 and 10 years old experience about a 2.5% larger annual price change, ceteris paribus; the t-value of greater than six for each of these two coefficients indicates strong statistical significance. Products between 2 and 4 and between 4 and 7 years old have slightly smaller price changes, but the t-values of less than one suggest that items from these age groups do not experience statistically significantly different price changes. Finally, products in the 10-25 age group (which includes in particular patent expired products) experience about a 0.8% larger annual price change relative to over age 25 products, but the 1.779 t-value implies statistical significance only at levels less than about 92.5%.

Table 5

Results from Revenue Weighted Age-Price Regressions
d log P as Dependent Variable
(Absolute value of t-statistics in parentheses)

	All Products		SIC 2834111 Only	
Regressor	(1)	(2)	(3)	(4)
CONSTANT	.0427	.0399	-.0321	-.0376
	(5.45)	(4.99)	(2.33)	(2.74)
D1986	.0122	.0129	-.0003	.0001
	(2.53)	(2.68)	(0.02)	(0.01)
D1987	-.0199	-.0194	.0017	.0028
	(4.36)	(4.27)	(0.12)	(0.21)
D1988	.0074	.0050	-.0564	-.0584
	(1.72)	(1.17)	(4.18)	(4.37)
D1989	-.0056	-.0048	-.0349	-.0308
	(1.34)	(1.16)	(2.42)	(2.15)
AGE(<2)	-.0347	-.0347	.0212	.0196
	(6.19)	(6.20)	(1.25)	(1.16)
AGE(2<4)	-.0040	-.0028	-.0399	-.0401
	(0.95)	(0.65)	(2.91)	(2.94)
AGE(4<7)	-.0024	-.0049	.0311	.0256
	(0.58)	(1.18)	(2.43)	(2.01)
AGE(7<10)	.0252	.0250	.0830	.0728
	(6.13)	(6.10)	(5.87)	(5.13)
AGE(10<25)	.0082	.0031	.0844	.0744
	(1.78)	(0.67)	(6.24)	(5.48)
BLSDUMMY	--	.0292		.0560
		(6.61)		(4.66)
R^2	.1632	.1695	.1746	.1901
N	5761	5761	1147	1147

Note: Regressions also included company dummies, and in the case of the all products regressions, SIC sub-class dummies.

We also ran a regression identical to (1) but with a dummy variable equal to one if the item were sampled by the BLS in the latter year; results are given in Column (2) of Table 5. The estimated coefficient on BLSDUMMY variable is .0292, with a t-value of 6.61, indicating that on average, items sampled by the BLS grew at an almost 3% larger AAGR than other items. Notice that this 2.92% coefficient is almost as large as the 3.06% difference between the growth rate of the official PPI for SIC 28341 (9.09%) and that for the Divisia index of our four-company sample (6.03%). The comparison with the Divisia index is appropriate here, for the dependent variable in these regressions are constructed similar to the price relatives of the Divisia index.

For our purposes, it is important to note that the two clearly significant age-related coefficients from the age-price regressions (1) and (2) of Table 5 coincide with the two age groups where the BLS sample and four-company universe revenue shares differ most dramatically -- under age two and between ages 7 and 10 (see Table 4). Thus there is clear evidence supporting the notion that, with respect to age, items undersampled by the BLS experience below-average price changes, while items oversampled by the BLS undergo above-average price changes.

To quantify the implications of this combined unrepresentative sampling - differential price change by age group phenomenon in unraveling our mystery in an alternative manner, we have constructed a simple accounting relationship. Let us predict total price growth as a function of revenue shares and age-specific price growth, separately for the items sampled by the BLS,

$$\frac{\dot{P}}{P}_{BLS} = \sum_{i=1}^{6} w_{i,BLS}\left[\frac{\dot{P}_i}{P_i}\right] . \qquad (1)$$

and for the four companies,

$$\frac{\dot{P}}{P}_{COM} = \sum_{i=1}^{6} w_{i,COM}\left[\frac{\dot{P}_i}{P_i}\right] . \qquad (2)$$

where the $\dot{P}_i/P_i$ are approximated by the regression coefficients from Table 5. Then subtract (2) from (1), impose the condition that the $w_{i,BLS}$ and the $w_{i,COM}$ weights each sum to unity over the six age-groups, and collect terms. This yields the expression

$$\frac{\dot{P}}{P}_{BLS} - \frac{\dot{P}}{P}_{COM} = \sum_{i=1}^{5}(w_{i,BLS} - w_{i,COM})\left[\frac{\dot{P}_i}{P_i} - \frac{\dot{P}_6}{P_6}\right] \qquad (3)$$

where the 6 subscript refers to the sixth age group (products over age 25). According to (3), the difference in predicted growth rates between the BLS and the four-company (COM) aggregate price indexes depends on corresponding differences in the w_i share weights times any differences in price changes by age group.

To see how this relationship helps to understand the difference between AAGR's of aggregate sampled and four-company universe price indexes, we employ the Table 4 entries to compute differences in share weights, and the parameter estimates of Columnn (1) in Table 5 to approximate the differentials in price growth by age group. Specifically, to reflect the BLS fixed weights within Cycles I and II, we use as estimates of the $w_{i,BLS}$ weights the arithmetic means of the 1984 and 1988 BLS weights in Table 4, and as estimates of the $w_{i,COM}$ fixed weights, we use the arithmetic mean of the 1984 and 1988 four-company universe weights. Substituting these values into equation (3), and noting that the aggregate price index of BLS sampled items grew at an AAGR of 8.94% while that for the universe of products at the four companies grew at an AAGR of 6.68%, we find that of the 2.26% difference in AAGR's (8.94% - 6.68%), 1.18% is "explained" by the right-hand side of equation (3) -- differences in share weights times differentials in rates of price change by age group.

This is a rather satisfying finding, for it implies that if one confines the analysis to differences between two Laspeyres-type indexes, this very simple accounting relationship can explain approximately 52% (1.18%/2.26%) of the difference in AAGR as being due to the BLS oversampling products with above-average price increases and undersampling of items with below-average price changes.[23]

We have also undertaken a similar analysis for the systemic anti-infectives sub-class of products. The regression equation we estimated is given in Column (3) of Table 5. As is seen there, ceteris paribus, products between 7 and 10, and between 10 and 25 years experience particularly large price increases, while young products undergo much smaller price changes. Further, when a BLS sampled item dummy variable was added to this equation (see Column 4 of Table 5), the estimated coefficient on the BLS dummy variable is .0560, with a t-value of 4.66. Hence, other things equal, for systemic anti-infectives, on average items sampled by the BLS grew at an AAGR of about 5.8% higher than all other items. Moreover, of the 6.28% difference in AAGR between BLS sampled (8.53%) and four-company universe (2.25%) items, 2.70% is "explained" by the right-hand side of equation (4); hence about 43% (2.70/6.28) of the discrepancy can be explained by differences in share weights and differentials in rates of price change by age group. For Cycle I, this proportion is 36% (1.89/5.27), while for Cycle II it is 38% (3.26/8.54).

It is worth emphasizing, however, that in this paper we do not ask why it is that the BLS oversamples medium-age products and undersamples newer products, nor do we pursue why it is that price changes for medium-age products tend to be larger than those for younger products.

V. YOUNG GOODS AND VARYING WEIGHTS

Having accounted for a substantal portion of the difference between two Laspeyres-type indexes on the basis of BLS non-representative sampling, we now turn our attention briefly to an examination of the role of relatively young goods and varying share weights in helping to understand the difference between a traditional Laspeyres and various other Laspeyres and Divisia indexes.

Recall that during Cycle I, the BLS sample frame consisted of products chosen in 1981, and that this set of sampled items remained until January 1988, when the new Cycle II sample frame was introduced. Since we do not know what the 1981 revenue shares were, in attempting to mimick the BLS procedures using a Laspeyres price index we have employed 1984 fixed quantity weights during Cycle I, and 1988 fixed quantity weights during Cycle II. This implies that goods introduced after January 1984 but within Cycle I were excluded until 1988, and goods introduced after January 1988 were excluded from Cycle II.

As is seen in Table 6, when this "usual Laspeyres" procedure is employed for all product classes in our four-company data, the AAGR during Cycle I, Cycle II and the total time period are 6.58%, 6.89%, and 6.68%, respectively, while the corresponding official PPI grew at 9.20%, 8.85% and 9.09%. Had the sample frame not changed in January 1988, had the quantity weights not been altered then, and thereby had all products introduced after January 1984 been completely excluded, the Laspeyres price index would haved grown at an AAGR of 9.69% instead of 6.89% during Cycle II, and 7.58% instead of 6.68% over the entire 1/84-12/89 time period. Hence, the changing of the sample frame in January 1988 had a substantial impact on the Laspeyres index.

With the Divisia index, the weights assigned to each product differ by month reflecting changing product market shares, and new goods are introduced immediately, thereby having an impact on the overall index. To consider the impact of the Cycle II sample frame change, we computed an alternative Divisia-type aggregate price index in which the set of goods during the Cycle I era consisted only of those present in January 1984, and the set of goods during Cycle II included only those present in January 1988, i.e. new goods were excluded except as of January 1988. Results from this calculation are also given in Table 6, where it is seen that allowing revenue share weights to change but restricting the set of products to incumbent ones except for a January 1988 update results in growth rates surprisingly similar to the traditional Laspeyres index -- 6.36% vs. 6.58% in Cycle I, 7.12% vs. 6.89% during Cycle II, and 6.61% vs. 6.68% overall. However, when the set of products used excludes all new goods (i.e., all products introduced after

Table 6

AAGR of Aggregate Price Indexes with Alternative Treatments of New Goods
Cycle I, Cycle II and Overall

All Products

	Cycle I 1/84-1/88	Cycle II 1/88-12/89	Total 1/84-12/89
Official PPI	9.20%	8.85%	9.09%
		Four-Company Data	
BLS Sampled Items - Usual Laspeyres	7.74	11.49	8.94
Laspeyres-Usual All items	6.58	6.89	6.68
Laspeyres-New goods completely excluded	6.58	9.69	7.58
Divisia-New goods excluded except update at 1/88	6.36	7.12	6.61
Divisia-New goods completely excluded	6.36	9.57	7.39
Divisia-Usual	5.43	7.31	6.03

January 1984), the fixed-weight Laspeyres and the varying-weight Divisia yield more discrepant growth rates -- 6.58% vs. 6.36% in Cycle I, 9.69% vs. 7.12% in Cycle II, and 7.58% vs. 6.61% overall. Finally, when new goods are introduced into the Divisia price index as soon as is feasible, the AAGR's fall considerably -- to 5.43% in Cycle I, 7.30% in Cycle II, and 6.03% overall.[24]

We conclude, therefore, that differences in AAGRs between the Laspeyres and Divisia indexes are rather modest, provided that computations are undertaken over an identical set of goods. However, when the set of goods included in the computations incorporates new and relatively young products immediately, the resulting Divisia indexes grow at a considerably slower rate than do the fixed-weight Laspeyres indexes that exclude these new goods. In the pharmaceutical industry, the role of new and relatively young goods is a significant one, and failing to incorporate new goods promptly into the price index calculations results in upward biased growth rates.

VI. CONCLUDING REMARKS

Our focus in this paper has been on why the official BLS price index grows approximately 50% more rapidly (9.09% vs. 6.03%) than a Divisia index, where the latter is computed using data on 2,090 products sold by four of the ten largest firms in the US pharmaceutical industry. These four firms comprised approximately 24% of total domestic industry sales in 1989.

The evidence we have presented suggests that, in terms of sampled items, the difference cannot be attributed to the four firms being unrepresentative of the industry as a whole, for growth rates of prices for items sampled by the BLS at the four firms are very close to that of the official PPI (8.94% vs. 9.09%). Moreover, when IMS data are employed for a sub-class of products (systemic anti-infectives) encompassing almost the entire universe of products, the difference in AAGR becomes even larger -- 6.26% for the official PPI vs. 1.54% for the Divisia index. An incidental finding is that for the 241 exact product matches between the IMS and four-company data sets, growth rates of prices are similar -- a similarity that gives us some confidence in using the

IMS data as a proxy for producer level price growth. Finally, differences between industry-wide and the four-firm product share distributions do not help explain the discrepancy, for differentials in AAGR's are essentially unaffected when Census-BLS industry sub-class weights are employed instead of those based on the four-firm data.

What is it about the BLS procedures that on average appear to miss the smaller price increases of representative transactions? Our analysis has demonstrated that a substantial proportion (about 50%) of the difference in AAGR's between prices reported by the four firms to the BLS and transactions prices for the four-firm universe of products can be attributed to the fact that the BLS tends to undersample younger products that experience less than average price increases, and oversample medium-age items that undergo above-average price increases. Why it is that the BLS undersamples younger and oversamples medium-age products is not clear to us, nor do we address in this paper the interesting issue of why medium-age products experience larger price increases than younger items.

We also find that differences in AAGRs between the Laspeyres and Divisia indexes are rather modest provided that computations are undertaken over an identical set of goods. However, when the set of goods included in the computations incorporates new and relatively young products, the resulting Divisia price indexes grow at a considerably slower rate than do the fixed-weight Laspeyres price indexes. In the US pharmaceutical industry from 1984 through 1989, the role of new and relatively young goods was a significant one, and failing to incorporate new goods promptly into the price index calculations appears to have resulted in upward biased growth rates.

It is worth emphasizing that the research reported here neglects entirely the fact that generic drugs could be linked to their patented antecedents, and that new drugs incorporating quality changes could be connected to their predecessors via hedonic procedures.[25] Since generic drugs are treated by the BLS as entirely new products and are not linked to patented progenitors, and since generics tend initially to be priced at lower levels than their patented competitors, we believe that the AAGR's of price indexes properly linking generics would be even lower than those reported in this paper. Work on this issue is currently underway involving systemic anti-infectives, as is an exploratory effort to determine whether it is feasible to undertake hedonic price analysis for cardiovascular drugs.

APPENDIX A:

FURTHER DETAILS ON THE PRODUCER PRICE INDEX FOR SIC 28341

Before 1978 the Producer Price Index was known as the Wholesale Price Index (WPI). The WPI originated from an 1891 U.S. Senate resolution authorizing the Senate Committee on Finance to investigate the effects of the tariff laws "upon the imports and exports, the growth, development, and prices of agricultural and manufactured articles at home and abroad."[26]

The BLS calulates the PPI according to a modified Laspeyres formula in which the value of base period quantities at current period prices is divided by the value of base period quantities at (perhaps temporally different) base period prices, i.e.,

$$I_t = [\sum Q_a P_t / \sum Q_a P_0] \cdot 100 = [(\sum Q_a P_0 (P_t/P_0)) / \sum Q_a P_0] \cdot 100, \qquad (1)$$

where Q_a represents the quantity shipped during the weight-base period, P_t is the current price of the commodity, P_0 is the price of the commodity in the comparison period, the summation is over i goods, but i subscripts are omitted.[27] Note that this index is a weighted average of price relatives P_t/P_0.

In the main text of this paper we outlined the process employed by the BLS in choosing establishments and products to sample. To understand this sampling process better, we now follow the BLS procedure and discuss its two distinct stages, in which the overall aim is to make the probability of selection proportional to a product's value of shipments (VOS). The first stage consists of choosing a random sample of establishments, drawn from Unemployment Insurance files. In the second stage, in principle specific products of that establishment are chosen with probability proportional to VOS, although in practice some products for SIC 2834 are certainty selected to ensure coverage of important items.[28] We now summarize these two stages.

All PPI's are routinely subject to monthly revision every month for four months after original publication (usually on the second or third Friday of the month following the reference month), to reflect late reports and corrections by company respondents. After four months, indexes are considered final.

The sampling frame for establishments is drawn from the Unemployment Insurance data files (as updated and refined by BLS personnel), and in almost all cases reported employment determines the probability of inclusion.[29] Although use of VOS to choose the establishment sampling frame would be preferable, the BLS justifies using employment as a proxy for VOS in the first stage since employment figures are more widely available for establishments than are data on VOS;[30] moreover, BLS asserts that UI "...is used as a proxy in sampling since the number of employees tends to be correlated with the revenue of a Profit Maximizing Center within a particular SIC."[31] If prices for several establishments are set at one location (called a Profit Maximizing Center), then the establishments (referred to as a cluster) are considered to be one establishment, and the reported employment figures are appropriately summed.

Once an establishment has been selected, in the second stage a BLS field representative visits it and conducts an interview designed to select the items to be priced and to collect base prices and value weights. In theory, the probability with which a product is selected, given choice of the establishment and the number of quotes assigned to it, is proportional to its VOS over the twelve months prior to the interview. In this disaggregation process, in principle, VOS-based sampling probabilities are employed, but detailed information on price-determining characteristics is required for only a small subset of products. This economy of required detail reduces the reporting burden on cooperating companies, and results in an initiation interview that is "usually completed within 2 hours."[32]

Within the disaggregation process, several additional steps occur. First, all products are categorized into broad product classes. A running total of the percent of VOS for each category is formed, and the number of price quotes to be taken from within each category is determined by randomly choosing a first percentile level and equally spacing the remaining quotes to be chosen.

For example, suppose there are three product categories and that five quotes are to be chosen for the establishment as a whole. Let the first category account for 50% of the VOS, the second for 30%, and the third for 20%; hence the running total is 50%, 80% and 100%. Since five quotes are to be chosen, a random percentile level from 1 to 20 is selected (note that 100%/5 = 20%). Suppose this random percentile level is 15.[33] Then the additional four quotes are equally spaced at intervals of 20; in this case, at 35, 55, 75 and 95. Because the 15th and 35th percentiles both fall within the first segment of the running total (0% - 50%), two quotes will be chosen from the first category. Similarly, 55 and 75 fall within the second segment, so two quotes will be chosen from the second category. Finally, one quote will come from the third category. This process of disaggregation is repeated within each category from the first stage until an individual product involved in a particular transaction is identified. The resulting unique transaction is then recorded in detail so that future price quotes can be accurately identified by the reporting establishment.

As was noted earlier, in some cases selected product categories are "certainty sampled" or "certainty selected". This can occur if it is felt by the BLS that some item is of particular importance, or may be so in the future.

In the 1987 sample for specified companies, both diabetes and cancer therapies are certainty selected. In this type of certainty selection, one item from within the chosen category is selected using normal disaggregation procedures (e.g., within SIC 2834 119 for cancer therapies, or within SIC 2834 127 for diabetes therapies), the VOS for the entire category is subtracted from the VOS of the establishment, the number of remaining selections is reduced by one, and the disaggregation process is begun again from the beginning (without the certainty selected category). This procedure is repeated for any additional certainty selected items. A second type of certainty sampling occurs whenever the percentage of VOS for a product class exceeds the sampling interval at that level of disaggregation.

For the pharmaceutical and paper mill industries, the Cycle II disaggregation procedure differed from that for most other industries in two respects. First, rather than allowing the establishment to determine the classes of products for the first step of the disaggregation process, the BLS provided a table of product categories. In most industries no more than eight categories are defined at each level of disaggregation, but in SIC 28341 there are 48 products within the prescription pharmaceuticals section. The other difference from normal disaggregation procedures is in the handling of the second type of certainty selection, mentioned at the end of the previous paragraph. The normal disaggregation procedure might result in "multiple hits", i.e. it might choose a given product more than once. To avoid this, if a category is wider than the sampling interval, then a product is chosen by disaggregation within the category, the VOS is deducted from the overall VOS for the establishment, and the process is started again with the certainty selected item removed. Hence multiple hits are not possible.[34]

Once the initiation interview is completed and the items for which price quotes are to be obtained are determined, repricing occurs with reporting taking place through the mail. From this the BLS obtains a time series of monthly price quotes for each item sampled, defined in such a way so as to make the item transacted and the transaction constant over time.

To construct PPI's, the sampled products are classified into cells, typically at the seven to nine digit SIC level; the within cell index weights are the VOS for the establishment divided by the number of quotes from the establishment. Note that an item with a small VOS is given the same within-cell weight as an item with a larger VOS, but that this is consistent with probability sampling proportional to VOS, for the small item essentially represents many other small items which, when combined, have the same probability of selection as a single, larger item with the same VOS. As we understand it, the within cell index is a fixed-base Laspeyres index adjusted from month to month so as to show no change when product deletions occur. Aggregated between-cell indexes are then created by weighting within-cell indexes by VOS within the cells produced within the same industry; these VOS are taken from the U.S. Department of Commerce, Census of Manufacturers.[35] Thus, shipment values for the same products made in other industries do not enter the weighting structure.[36] The total value of shipments for each industry is then distributed among the products or other revenue sources produced by that industry, thereby eliminating the need for indirect weight imputations, a practice that was common under the pre-1978 methodology of the PPI.

FOOTNOTES

[1]Irving Fisher [1922], p. 360.

[2]Specifically, fixed weights are linked in January 1988, corresponding with the BLS change in moving from Cycle I to Cycle II sampling.

[3]This paper extends and builds on the preliminary findings and conjectures reported in Berndt, Griliches and Rosett [1990].

[4]This issue has been examined by George J. Stigler and James K. Kindahl [1970], who found that overall, although there was little difference between the trend of BLS and transactions prices from 1957 to 1961, from 1961 to 1966 the BLS price index rose about 0.7% more rapidly than an index based on transactions prices. For the ethical pharmaceutical preparations industry, however, Stigler-Kindahl found no appreciable difference between BLS and transactions prices.

[5]Much of the material in this Appendix is taken from Berndt, Griliches and Rosett [1990].

[6]Some products were deleted from or added to this list during the 1984-89 time period.

[7]There is some confusion concerning the treatment of production in Puerto Rico. A substantial amount of pharmaceutical preparations production occurs in Puerto Rico, and while production establishments are not sampled by the BLS in Puerto Rico, from conversations with company officials we are led to believe that in reporting data to the BLS the firms treat Puerto Rico as domestic.

[8]Since no industry publication provides a classification of prescription pharmaceuticals by 7-digit SIC code, we worked with company officials and examined the Physicians' Desk Reference [1990] and Drug Facts and Comparisons [1991] in undertaking such a classification. In some cases, however, judgment was necessary, for occasionally a drug could be envisaged as being in more than one sub-class. Overall price and sales data were given us for 2,551 products, of which 207 were classified as non-prescription. In addition, we were unable to assign detailed SIC classes for 254 products. The non-prescription items accounted for only 1.10% of total revenues, and the unclassified items accounted for but 0.53% of total revenues.

[9]IMS America, 660 W. Germantown Pike, Plymouth Meeting, Pennsylvania 19462 (telephone 215-834-5000).

[10]This discussion is based in large part on summary information provided us by IMS America in the "front pages" of audit information for U.S. Drugstore and U.S. Hospital.

[11]Average prices are often lower to hospitals than to other outlets.

[12]Overall, 341 matches were made between IMS and 4-company products. 100 were deleted, as 45 had no common-month prices, 38 had few and highly volatile prices reported by the companies, and 17 were entrants or exits where movements of initial or final sales by producers through the distribution chain caused poor contemporaneous tracking in the IMS data.

[13]The AAGR of the Divisia index (using four-company revenue weights) for IMS

data was 4.12%, while that for the matched four-company products was 3.27%. Since the four-company Divisia for all products in SIC 2834111 grows at but 1.20% per year, we interpret the higher growth rates of these common items as reflecting the fact that the matched products omit new goods and therefore represent more mature, established products. Recall from the previous footnote that typically new goods are poorly tracked by IMS as they initially enter the distribution chain.

[14]It might be noted, however, that contemporaneous correlations of monthly log price changes between IMS and company data are typically very low -- often less than 0.02. However, for annualized prices, the revenue-weighted correlations exceed 0.5.

[15]Parallel AAGR's over the same 10/84 - 12/89 time period for the four-company products in SIC 2834111 are 1.96% for the Laspeyres and 1.15% for the Divisia. We had expected the IMS prices to grow at a slower rate than those in the four-company data, in part because the IMS data include generic drugs. Why this inequality occurs is a topic worthy of further consideration.

[16]Monthly total revenue data by therapeutic class were purchased from IMS.

[17]This smoothing procedure was employed to mitigate the problem of "drift" that occurs with chained indexes such as the Divisia. For further discussion, see Berndt, Griliches and Rosett [1990], as well as Barzel [1963], Frisch [1936] and Szulc [1983].

[18]This Laspeyres calculation uses company quantities as weights, and links them in January 1988 to reflect the BLS splice between Cycles I and II. For Cycle I, the AAGR of reported prices was 7.74%, while for transactions prices it was 8.97%; for Cycle II, the respective growth rates are 11.49% and 10.69%.

[19]For Cycle I, reported and average transactions prices of SIC 2834111 sampled items grew at an AAGR of 7.64% and 7.63%, respectively, while for Cycle II the growth rates are 10.43% and 10.64%.

[20]See, for example, W. Erwin Diewert [1988] and the references cited therein.

[21]Alternative presentations of the same product introduced at different dates are treated as such, i.e., we do not treat alternative treatments as all being introduced at the time the initial presentation was brought to market.

[22]Revenue shares are computed as the arithmetic mean of the shares in the two years.

[23]When a similar analysis is done separately for Cycles I and, we find that of the 1.16% difference in AAGR in Cycle I, the right-hand side of equation (4) explains 1.57% (or more than the entire difference), while in Cycle II the relationship explains 1.15% of the 4.60% difference in AAGR's.

[24]It would have been desirable to undertake a similar analysis using the IMS data, but at this point in time we have not been able to obtain data on product introduction dates for the items in that data set.

[25]For an example in the context of personal computers, see Berndt-Griliches [1990].

[26]See U.S. Senate Committee on Finance [1893].

[27]Note that the summation counter is not specified in (1), and generally requires an additional subscript. Also, the BLS Handbook (BLS, Bulletin 2285 [1988], p. 130) states that "The expression (Q_aP_0) represents the weight in value form, and the P and Q elements (both of which originally relate to period "a" but are adjusted for price change to period "0") are not derived separately."

[28]In U. S. Department of Labor [undated, a], it is stated that "For specified companies, both cancer therapy and diabetes preparation drugs are being certainty selected."

[29]Discussions with BLS personnel indicate that in some cases where value of shipment data is intact and complete for establishments, VOS rather than UI data are used to compute probabilities of inclusion.

[30]As Hill [1987, p. 583] notes, "By law, every employer in the U.S. is required to report the number of people employed and to purchase insurance which will cover the employer's unemployment benefit liability. As a result the UI file data are fairly complete. The continued existence of the UI file is also assured, thereby ensuring continued availability of a consistent frame for sampling. The UI file contains such information as the establishment's name, the SIC in which it is classified, the county and state in which it is located, and its number of employees. This file is explicitly stratified according to industry classification and thus provides individual industry frames which form the basis for the PPI frames."

[31]Hill [1987], p. 584.

[32]U. S. Department of Labor [1988, p. 128].

[33]Random numbers are presented on the bottoms of pages in the forms filled out by BLS field representatives.

[34]However, there is some ambiguity here. Although the wording in the BLS discussion of special disaggregation procedures (U. S. Department of Labor [1986a]) explicitly states that the entire cell is discarded once the certainty selection occurs, our sample from one company contains multiple selections from individual cells.

[35]An adjustment is made for inter- and intra-industry transfers to remove non-final product values from the weights, thereby obtaining net output values of shipments as weights. Currently the adjustment factor is based on the 1977 Input-Output tables from the Bureau of Economic Analysis, U. S. Department of Commerce.

[36]For further discussion, see U. S. Department of Labor [1988, p. 129].

REFERENCES

Barzel, Yoram [1963], "Some Observations on the Index Number Problem," Econometrica, 3:1, July, 391-399.

Berndt, Ernst R. and Zvi Griliches [1990], "Price Indexes for Microcomputers: An Exploratory Study," Cambridge, MA: National Bureau of Economic Research, Working Paper No. 3378, June.

Berndt, Ernst R., Zvi Griliches and Joshua Rosett [1990], "On the Accuracy of Producer Price Indexes for Pharmaceutical Preparations: An Audit Based On Detailed Firm-Specific Data," Cambridge, MA: National Bureau of Economic Research, Working Paper No. 3490, October.

Diewert, W. Erwin [1988], "The Early History of Price Index Research," Cambridge, MA: National Bureau of Economic Research, Working Paper No. 2713, September.

Drug Facts and Comparisons [1991], St. Louis, Mo: J. P. Lippincott Company, Facts and Comparisons Division.

Fisher, Irving [1922], The Making of Index Numbers, Cambridge, MA: Houghton Mifflin Company.

Frisch, Ragnar [1936], "Annual Survey of General Economic Theory: The Problem of Index Numbers," Econometrica, 4:1, January, 1-38.

Gousen, Sarah, Kathy Monk and Irwin Gerduk [1986], Producer Price Measurement: Concepts and Methods, Washington, DC: U. S. Department of Labor, Bureau of Labor Statistics, xerolith, June.

Hill, Kimberley Dailey [1987], "Survey Design in the Producer Price Index," 1987 Proceedings of the Section on Survey Research Methods of the American Statistical Association, Washington, DC: American Statistical Association, pp. 583-588.

Hulten, Charles R. [1973], "Divisia Index Numbers," Econometrica, 41:6, November, 1017-1025.

Physicians' Desk Reference [1990], Oradell, NJ: The Medical Economics Company Inc.

Stigler, George J. and James K. Kindahl [1970], The Behavior of Industrial Prices, NBER General Series No. 90, New York: Columbia University Press for the National Bureau of Economic Research.

Szulc, Bohdan J. [1983], "Linking Price Index Numbers," in W. Erwin Diewert and Claude Montmarquette, eds., Price Level Measurement, Proceedings from a Conference Sponsored by Statistics Canada, Ottawa: Minister of Supply and Services Canada, pp. 537-566, October.

U. S. Department of Labor [1989], "The Producer Price Index: An Introduction to its Derivation and Uses," Washington, DC: Bureau of Labor Statistics, March.

U. S. Department of Labor [1988], "Producer Prices," chapter 16 from BLS Handbook of Methods, Washington, DC: Bureau of Labor Statistics, Bulletin 2285, April, pp. 125-137.

U. S. Department of Labor [1986a], Data Collection Manual: Producer Price Index, Washington, DC: U. S. Government Printing Office for the Bureau of Labor Statistics, 1986-491-543-54349, July.

U. S. Department of Labor [1986b], Producer Price Measurement: Concepts and Methods, Washington, DC: Bureau of Labor Statistics, June.

U. S. Senate Committee on Finance [1893], Wholesale Prices, Wages, and Transportation, Senate Report No. 1394, "The Aldrich Report," Part I, 52nd Congress, 2nd Session, March 3, 1893.