

## Trends in Vaccine Prices, 1992-2002

Frank R. Lichtenberg  
Columbia University and NBER

revised 18 October 2002

### Executive summary

We analyze the behavior of prices paid for vaccines by the Federal government during the period 1992-2002, using data from two different sources: the Federal Supply Schedule (FSS) and the Centers for Disease Control (CDC). Unfortunately, we were unable to obtain reliable data on prices paid for vaccines by non-Federal purchasers.

We construct price indexes that compare the price of a vaccine in a given year to the price of the same vaccine in another year. Our indexes do *not* compare prices of different vaccines (e.g. new vs. old vaccines).

We find that, in general, *the real (inflation-adjusted) price of a given vaccine today is lower than it was a decade ago*. The FSS data imply that the real price of vaccines was 18% higher in 1993 than it was in 2002. The CDC data imply that the real price of vaccines was 7% higher in 1992 than it was in 2002. The latter figure is probably more reliable, because our CDC index weights vaccines by their market value, whereas our FSS index gives equal weight to all vaccines.

*Although the real price of vaccines declined over the course of the last decade, it has increased significantly in the last three years*. Both the FSS and the CDC price indexes indicate that the real price of vaccines increased about 9% from 1999 to 2002. Before 1999, nominal vaccine prices increased much more slowly than the CPI, and may even have declined. Since 1999, nominal vaccine prices increased about 3% per year faster than the CPI.

*The time-series behavior of vaccine market concentration resembles the behavior of vaccine prices*: concentration declined fairly steadily from 1992 to 1999, and increased sharply after 1999. Analysis of *the FSS data revealed a statistically significant correlation across vaccines between price changes and changes in market structure*. Those data indicated that when the status of a vaccine changes from multi-source to sole-source, the price of the vaccine tends to increase by about 10%. However *the CDC data provided only weak evidence for a price-concentration correlation*, and indicated that only about 15% of the 1999-2002 increase in the CDC vaccine price index was “explained by” the increase in vaccine market concentration. Moreover, changes in both price and concentration may have been due to other, unobserved factors

## Data sources

We were able to obtain comprehensive data on prices paid for vaccines by the Federal government during the period 1992-2002 from two different sources: the Federal Supply Schedule (FSS, published by the Veterans Administration)<sup>1</sup>, and the Centers for Disease Control (CDC). Unfortunately, we were unable to obtain reliable data on prices paid for vaccines by non-Federal purchasers.

## Evidence from the Federal Supply Schedule

The FSS provides data on contract prices for pharmaceutical products (including vaccines) purchased by the Federal government. Each record in the Federal Supply Schedule Pharmaceutical Price database indicates the FSS Contract Number, the contract start date (date the price is effective), the contract end date (last date the price is valid), the National Drug Code (NDC) number, and the FSS price.

Multum's Lexicon database (<http://www.multum.com/>) provides information about all pharmaceutical products, arranged by NDC code, including the product's active ingredient(s), therapeutic class, brand name, and manufacturer. I merged the FSS data with the Multum data, by NDC code, and retained records for products that Multum classifies as vaccines.<sup>2</sup> The resulting database contained data on 26 distinct active ingredients, 43 distinct brands, and 130 distinct products.<sup>3</sup>

A relatively simple, meaningful way to examine price trends is to estimate models of the form

$$\log(\text{price}_{ijt}) = \alpha_i + \beta t + \varepsilon_{ijt} \quad (1)$$

and

$$\log(\text{price}_{ijt}) = \alpha_i + \beta_j t + \varepsilon_{ijt} \quad (2)$$

where

$\text{price}_{ijt}$  = is the price of product (NDC code)  $i$  in category  $j$  in year  $t$ , where category may refer to the active ingredient, brand, or manufacturer. This model includes a fixed effect for each product, so that we are comparing the price of a product at time  $t+k$  to the price of the same product at time  $t$ .  $\beta$  represents the overall (unweighted<sup>4</sup>) average annual rate of price increase, and  $\beta_j$  represents the average annual rate of price increase of products in category  $j$ .

<sup>1</sup> The VA publishes current contract prices on its website <http://www.vapbm.org/PBM/prices.htm>. The VA honored my request to provide unpublished historical price data.

<sup>2</sup> Appendix Table 1 provides a list of bacterial and viral vaccines and toxoids from the Multum database.

<sup>3</sup> Each package size of a given brand is a different product.

<sup>4</sup> Value- or quantity-weighted estimation is preferable, but we lack data on quantities purchased.

When we estimate eq.(1), the estimate of  $\beta$  is .0054 (t-stat=3.01). This implies that *the overall unweighted average annual rate of FSS price increase of vaccine products during the period 1993-2002 was 0.54%*. During the same period, the average annual rate of increase of the Consumer Price Index (CPI) was 2.44%. Hence this implies that the *real FSS price (the ratio of the nominal FSS price to the CPI) declined at an average annual rate of 1.90%*.

We also estimated a variant of eq. (1), in which the continuous variable t was replaced by a set of year dummies. The coefficients on these year dummies, which may be considered values of an FSS vaccine price index, are shown in Figure 1.

*They suggest that vaccine prices tended to decline between 1993 and 1999—especially during 1996-1998—but that vaccine prices increased about 18% between 1999 and 2001.*

As Figure 2 indicates, between 1993 and 1999, the FSS price index declined 11%, while the CPI increased 15%. Hence, the real or relative price of vaccines decreased about 26% in this period. In contrast, from 1999 to 2002, the vaccine price index increased 19%, while the CPI increased by 8%: the real or relative price of vaccines increased about 11% in this period.

Now I will present estimates of  $\beta_j$  from eq. (2), i.e., estimates of (nominal) price increase by active ingredient, manufacturer, and brand. Estimates by active ingredient, ranked by rate of price increase, are shown in the following table.

<b>active ingredient</b>	<b>Average annual rate of price increase</b>	<b>Std. error</b>	<b>t-stat</b>	<b>p-value</b>
s typhi (ty-2 strain)	-34.3%	1.1%	-32.67	<.0001
diphtheria protein	-10.0%	1.3%	-7.42	<.0001
hepatitis B vacc	-5.4%	0.3%	-15.59	<.0001
hepatitis A viru	-5.2%	0.5%	-10.25	<.0001
haemophilus caps	-3.8%	0.8%	-4.63	<.0001
Lyme Disease vac	-1.2%	3.0%	-0.39	0.6943
bcg, tice strain	-0.5%	2.3%	-0.21	0.8352
rotavirus vaccin	0.0%	15.0%	0	1
staphage lysate	0.0%	4.0%	0	1
polio vaccine, o	0.9%	1.1%	0.85	0.3937
pneumococcal 7- v	1.2%	6.9%	0.17	0.8613
varicella virus	1.5%	1.1%	1.42	0.1555
nonviable S. typ	1.8%	1.1%	1.68	0.093
diphtheria toxoi	2.0%	1.0%	2.1	0.0355
rubella virus va	2.3%	0.7%	3.22	0.0013
mumps virus vacc	2.4%	0.7%	3.59	0.0003

measles virus va	2.4%	0.5%	5.23	<.0001
pneumococcal pol	2.9%	0.6%	5.21	<.0001
vibrio cholerae	5.1%	1.1%	4.82	<.0001
rabies antigen	6.7%	0.8%	8.21	<.0001
influenza virus	6.8%	10.5%	0.65	0.516
typhoid Vi polys	9.0%	1.1%	8.6	<.0001
japanese enceph	11.3%	0.9%	12.8	<.0001
polio vaccine, i	12.8%	1.0%	13.17	<.0001
meningococcal po	13.8%	1.0%	14.16	<.0001
yellow-fever vir	17.1%	0.8%	21.6	<.0001

The median rate of price increase was about 2%. Two active ingredients evidently had very large price decreases (10% or more per year); four had large increases (10% or more per year).

Now we examine nominal price increases by manufacturer. These are shown in the following table and graphed in Figure 3.

Source	Average annual rate of price increase	Std. error	t-stat	p-value
Wyeth-Ayerst Lab	-14.4%	0.8%	-18.34	<.0001
SmithKline Beech	-6.1%	0.5%	-12.72	<.0001
Merck & Co., Inc	-0.8%	0.2%	-3.2	0.0014
Delmont Laborato	0.0%	4.2%	0	1
Lederle Laborato	0.1%	0.6%	0.21	0.8365
Organon	1.1%	3.1%	0.34	0.7313
Chiron Therapeut	1.3%	3.1%	0.43	0.6697
Berna	1.8%	1.1%	1.58	0.1146
Parke-Davis	9.6%	13.7%	0.7	0.4828
Aventis Pharmace	10.7%	0.4%	29.35	<.0001

Six of the ten manufacturers had annual price increase rates between -1% and +2%. Two had large (> 6%) and statistically significant decreases, and one (Aventis) had a large and statistically significant increase.

The following table shows data on rates of nominal price increase, by brand.

Brand	Average annual rate of price increase	Std. error	t-stat	p-value
Typhoid Vaccine	-34.3%	1.0%	-32.85	<.0001

Omnihib	-10.4%	1.9%	-5.43	<.0001
Havrix	-10.3%	1.1%	-9.00	<.0001
Hibtiter	-10.0%	1.3%	-7.46	<.0001
Engerix- B Pediat	-9.2%	0.9%	-10.72	<.0001
Recombivax HB	-5.2%	0.4%	-12.12	<.0001
Vaqta	-4.4%	0.6%	-6.90	<.0001
Comvax	-3.9%	1.6%	-2.52	0.0117
Rabies Vaccine	-3.5%	2.1%	-1.69	0.091
TheraCys Intrave	-3.1%	4.1%	-0.75	0.4514
Pedvax HIB	-3.1%	1.4%	-2.30	0.0213
Theracys 3	-3.1%	9.1%	-0.34	0.7318
Engerix- B	-2.9%	0.8%	-3.76	0.0002
Havrix Pediatric	-2.5%	1.3%	-1.99	0.0465
LYMERix	-1.2%	3.0%	-0.40	0.6927
RotaShield	0.0%	14.9%	0.00	1
Staphage Lysate	0.0%	3.9%	0.00	1
Orimune	0.9%	1.0%	0.86	0.3911
Tice BCG Vaccine	1.1%	2.9%	0.37	0.7132
Prevnar	1.2%	6.9%	0.18	0.8605
Acthib	1.3%	1.8%	0.72	0.4738
RabAvert	1.3%	2.9%	0.46	0.648
Influenza Virus	1.3%	17.8%	0.07	0.9407
Varivax	1.5%	1.1%	1.43	0.1533
Vivotif Berna	1.8%	1.1%	1.69	0.0912
Prohibit	2.0%	1.0%	2.11	0.0345
Biavax II	2.1%	1.8%	1.15	0.2515
Meruvax II	2.3%	0.7%	3.24	0.0012
M-M-R II	2.4%	0.7%	3.37	0.0008
Mumpsvox	2.4%	0.7%	3.43	0.0006
M-R- Vax II	2.4%	1.2%	2.05	0.0401
Attenuvax	2.5%	0.7%	3.48	0.0005
Pnu-Imune 23	2.6%	0.7%	3.64	0.0003
Pneumovax 23	3.4%	0.9%	3.82	0.0001
Cholera Vaccine	5.1%	1.0%	4.85	<.0001
Imovax Rabies I.	8.8%	1.6%	5.42	<.0001
Typhim VI	9.0%	1.0%	8.65	<.0001
Imovax Rabies	9.4%	1.1%	8.46	<.0001
Fluogen	9.6%	12.8%	0.75	0.4525
Je- Vax	11.3%	0.9%	12.87	<.0001
Ipol	12.8%	1.0%	13.25	<.0001
Menomune A/C/Y/W	13.8%	1.0%	14.23	<.0001
YF- Vax	17.1%	0.8%	21.72	<.0001

So far, I have attempted to *characterize* vaccine price behavior. I conclude this analysis with one limited attempt to *explain* this behavior. I hypothesize that changes in market structure—the number of manufacturers with contracts to sell a given ingredient to the Federal government—are associated with price changes. To test this hypothesis, I estimate the following generalization of eq. (1):<sup>5</sup>

$$\log(\text{price}_{ijt}) = \alpha_i + \beta t + \gamma \text{sole\_source}_{ijt} + \varepsilon_{ijt} \quad (3)$$

where

$\text{sole\_source}_{ijt}$  = 1 if there is only one manufacturer in period  $t$  of the active ingredient contained in product  $i$  in category  $j$   
= 0 otherwise

The estimate of  $\gamma$  is 0.105 (t-stat=2.50; p-value=.012). This suggests that when the status of a product changes from sole-source to multi-source, the price of the product tends to decrease by about 10%. Conversely, *when the status of a product changes from multi-source to sole-source, the price of the product tends to increase by about 10%*.

### **Evidence from the CDC data**

CDC provided data on the prices<sup>6</sup> it paid and the quantities it purchased, by supplier, of 13 vaccines (DTP, DtaP, Hep A, Hep B (ped. & adult), Hib, INFLUENZA, IPV, MMR, OPV, PCV-7, PNEUMO (adult), Td, Varicella) during the period 1992-2002.

We estimated a version of equation 1 in which  $i$  denotes vaccine  $i$  ( $i = 1, 2, \dots, 13$ ), and the continuous variable  $t$  was replaced by a set of year dummies. The model was estimated via weighted least squares, where the weight was equal to the market value (price times quantity) of that vaccine in that year. The coefficients on these year dummies, which may be considered values of a CDC vaccine price index, are shown in Figure 4. Nominal FSS and CDC vaccine price indexes are compared in Figure 5.

The CDC data indicate that the nominal price of vaccines was quite stable from 1992 to 1995. It increased about 7% in 1996, but then declined, and was at about the same level in 1999 as it had been in 1992. Since the CPI increased by 15% between 1992 and 1999, this implies that the real or relative price of vaccines declined by about 15% between 1992 and 1999. However between 1999 and 2002, the nominal price of vaccines purchased by CDC increased 20%, and the real price increased 12%.

Average annual rates of price change, by vaccine, ranked in descending order of rate of price increase, are shown in the following table:

<sup>5</sup> The equation I estimated includes time dummies rather than a time trend.

<sup>6</sup> CDC provided information about both the price including excise tax and the price excluding excise tax. We will analyze the behavior of the price excluding excise tax.

Vaccine	Average annual rate of price change	Standard Error	t Value	Pr >  t
Td	0.50	0.13	3.87	0.00
INFLUENZA	0.24	0.07	3.60	0.00
PNEUMO (adult)	0.09	0.19	0.47	0.64
IPV	0.07	0.03	2.80	0.01
OPV	0.05	0.03	1.63	0.10
Varicella	0.04	0.03	1.46	0.15
Hep B (ped&adult)	0.03	0.01	-4.51	0.00
Hib	0.03	0.02	1.53	0.13
PCV-7	0.02	0.04	0.49	0.63
DTP	0.00	0.09	-0.02	0.98
Hep A	0.00	0.04	-0.07	0.95
MMR	0.00	0.01	-0.58	0.56
DTaP	-0.01	0.01	-0.43	0.67

The CDC data provide another opportunity to test the hypothesis that changes in market structure are associated with price changes. These data enable us to compute the sales (quantity times price) of each vaccine by each supplier in each year. Hence, we can calculate the Hirschman-Herfindahl Index (HHI) of the market for vaccine  $i$  in year  $t$ . The HHI is the sum of squared market shares (expressed as percentages) of the suppliers in a market. If there is only one supplier, with a market share of 100%, the HHI is 10,000 ( $= 100^2$ ). If there are two suppliers with equal sales, the HHI is 5,000 ( $= 50^2 + 50^2$ ). The HHI is a useful index of market concentration. (The ratio 10000/HHI indicates the equivalent number of equal-sized firms in a market.)

To examine the relationship between price changes and changes in market structure, I estimated the following equation via weighted least-squares:

$$\log(\text{price}_{it}) = \alpha_i + \beta_t + \gamma \text{HHI}_{it} + \varepsilon_{it} \quad (4)$$

where

$\text{price}_{it}$  = the (weighted) average price of vaccine  $i$  in year  $t$ , and  
 $\text{HHI}_{it}$  = the Hirschman-Herfindahl Index (HHI) of the market for vaccine  $i$  in year  $t$ .

The estimated coefficient (t-ratio) on HHI was 0.0000136 (1.38), which is not statistically significantly different from zero ( $p\text{-value}=.17$ ). This provides only weak support for the hypothesis that vaccine prices increased fastest in markets with the greatest increases in concentration. To get a feel for the magnitude of this effect, suppose that market structure changed from a duopoly of two equal-sized suppliers to a monopoly, so that the HHI increased from 5,000 to 10,000. The estimate of  $\gamma$  indicates that this would be associated with about a 6.8% increase in the price of the vaccine ( $\gamma * \Delta\text{HHI} = 0.0000136$

\*  $5000 = 0.068$ ). This is about two-thirds as large an increase as the one we estimated from the FSS data.

Eq. (4) includes “year effects” ( $\beta_t$ 's), so it implicitly analyzes the relationship between price deviations and HHI deviations from year means. Figure 6 shows how weighted (by market value) average concentration changed over time. Concentration declined fairly steadily from 1992 to 1999, and increased sharply after 1999. (2002 data are incomplete and may not be meaningful.)

Figure 7 juxtaposes the CDC vaccine price index and the average vaccine market HHI. The two series appear to track each other quite closely, especially since 1996. But because the estimated relationship between the vaccine price and the HHI is rather weak, our estimates imply that only about 15% of the 1999-2002 increase in the CDC vaccine price index was “explained by” the increase in vaccine market concentration.

Moreover, an important caveat concerning our findings about concentration and price should be borne in mind. Even when concentration and price are positively *correlated*, changes in concentration may not have *caused* changes in price. Changes in both variables may have been due to other, unobserved factors. For example, exogenous changes in production costs (and in the relative production costs of different suppliers) may have caused changes in both concentration and price. As Carlton and Perloff<sup>7</sup> argue, “the degree of concentration in an industry is not a proper variable with which to explain performance; rather, concentration and performance should be explained simultaneously.” Unfortunately, due to data limitations, this is infeasible in most studies, including the present one.

---

<sup>7</sup> Carlton, Dennis, and Jeffrey Perloff, *Modern Industrial Organization* (Scott, Foresman, 1990), p. 382.

**Appendix Table 1**  
**Multum bacterial vaccines, toxoids, and viral vaccines (active ingredients)**

**bacterial vaccines**

bcg, tice strain	pneumococcal 7-valent conjugate
diphtheria protein	pneumococcal polysaccharides (23)
diphtheria toxoid protein	rabies antigen
haemophilus capsular oligosaccharide	s typhi (ty-2 strain)
Lyme Disease vaccine (recombinant OspA)	staphage lysate (SPL)
meningococcal polysaccharides A	tetanus toxoid
neisseria meningitidis	typhoid Vi polysaccharide vaccine
nonviable S. typhi	viable S. typhi
plague bacilli, killed	vibrio cholerae (Inaba)
	vibrio cholerae (Ogawa)

**toxoids**

diphtheria	pertussis, acellular
diphtheria, pertussis, tetanus vaccine	pertussis, whole cell
h influenzae type b	tetanus
haemophilus capsular oligosaccharide	tetanus toxoid

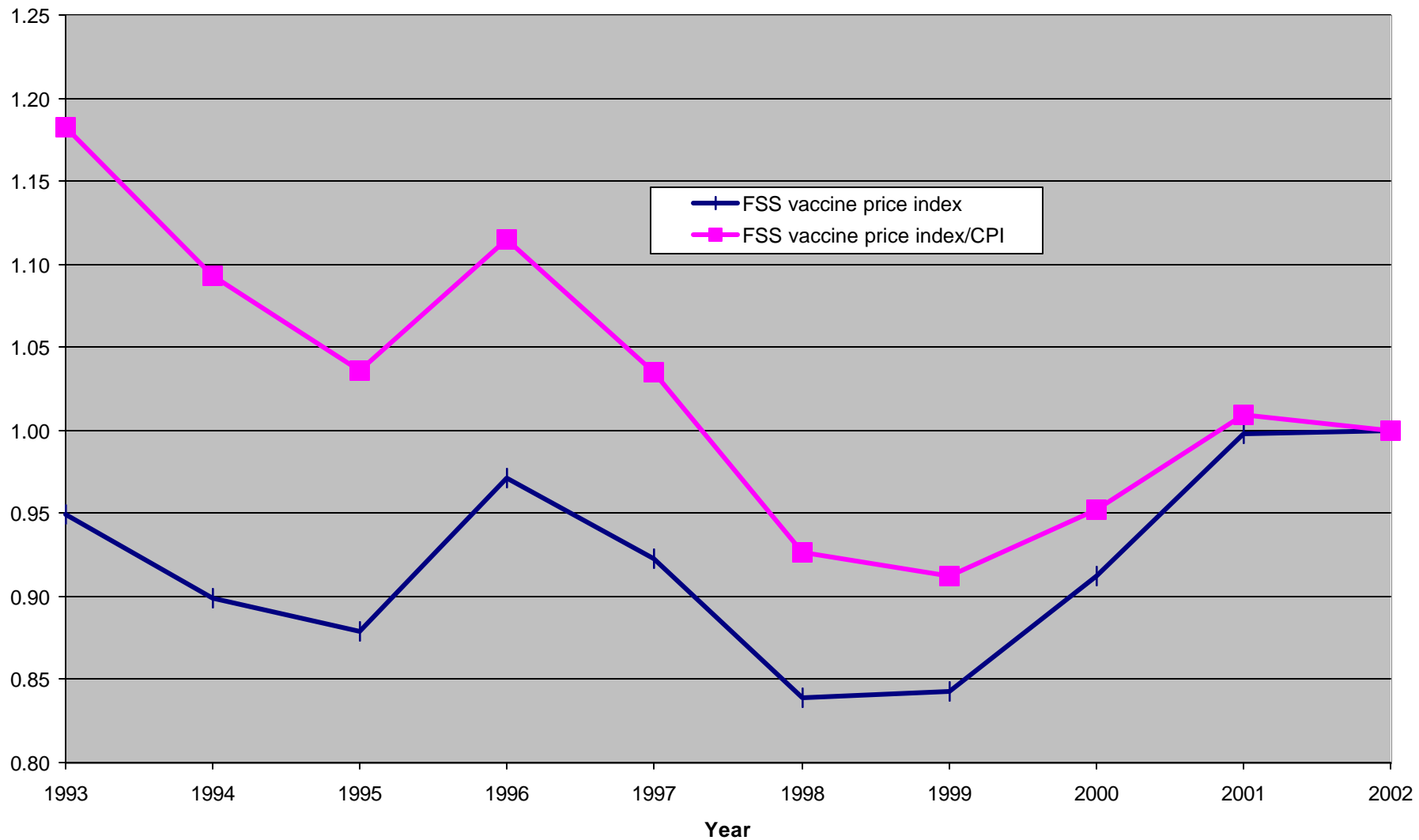
**viral vaccines**

haemophilus capsular oligosaccharide	mumps virus vaccine, live
hepatitis A virus vaccine	neisseria meningitidis
hepatitis b surface antigen	polio vaccine, inactivated (monkey kidney)
hepatitis B vaccine recombinant	polio vaccine, oral live
influenza virus vaccine	rotavirus vaccine, live, oral, tetravalent
japanese encephalitis virus vaccine	rubella virus vaccine
measles virus vaccine	varicella virus
	yellow-fever virus

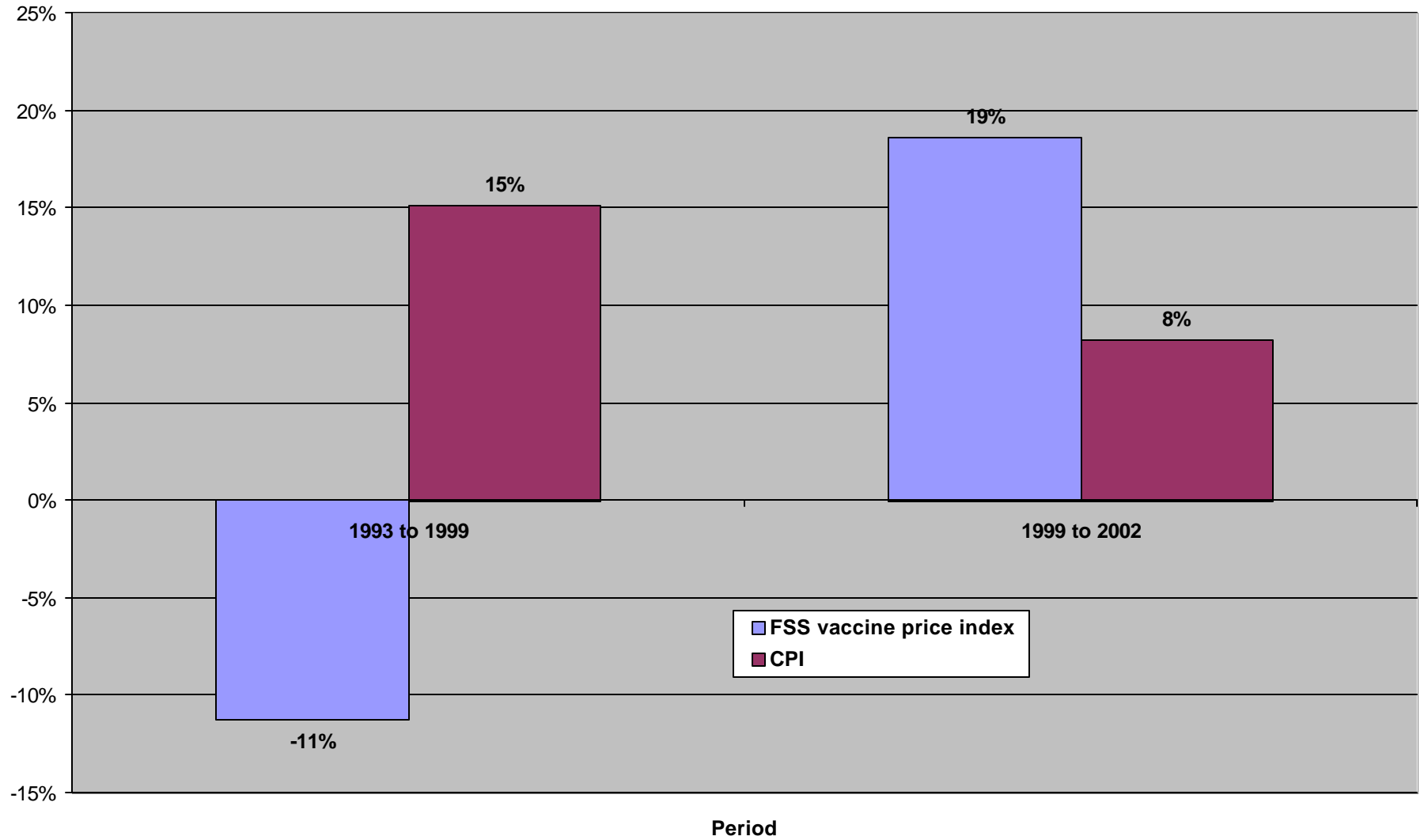
Appendix Table 2  
Price indexes

<b>year</b>	<b>FSS vaccine price index</b>	<b>CDC vaccine price index</b>	<b>CPI</b>
1992		0.83	0.78
1993	0.95	0.83	0.80
1994	0.90	0.83	0.82
1995	0.88	0.84	0.85
1996	0.97	0.91	0.87
1997	0.92	0.89	0.89
1998	0.84	0.84	0.91
1999	0.84	0.84	0.92
2000	0.91	0.88	0.96
2001	1.00	0.93	0.99
2002	1.00	1.00	1.00

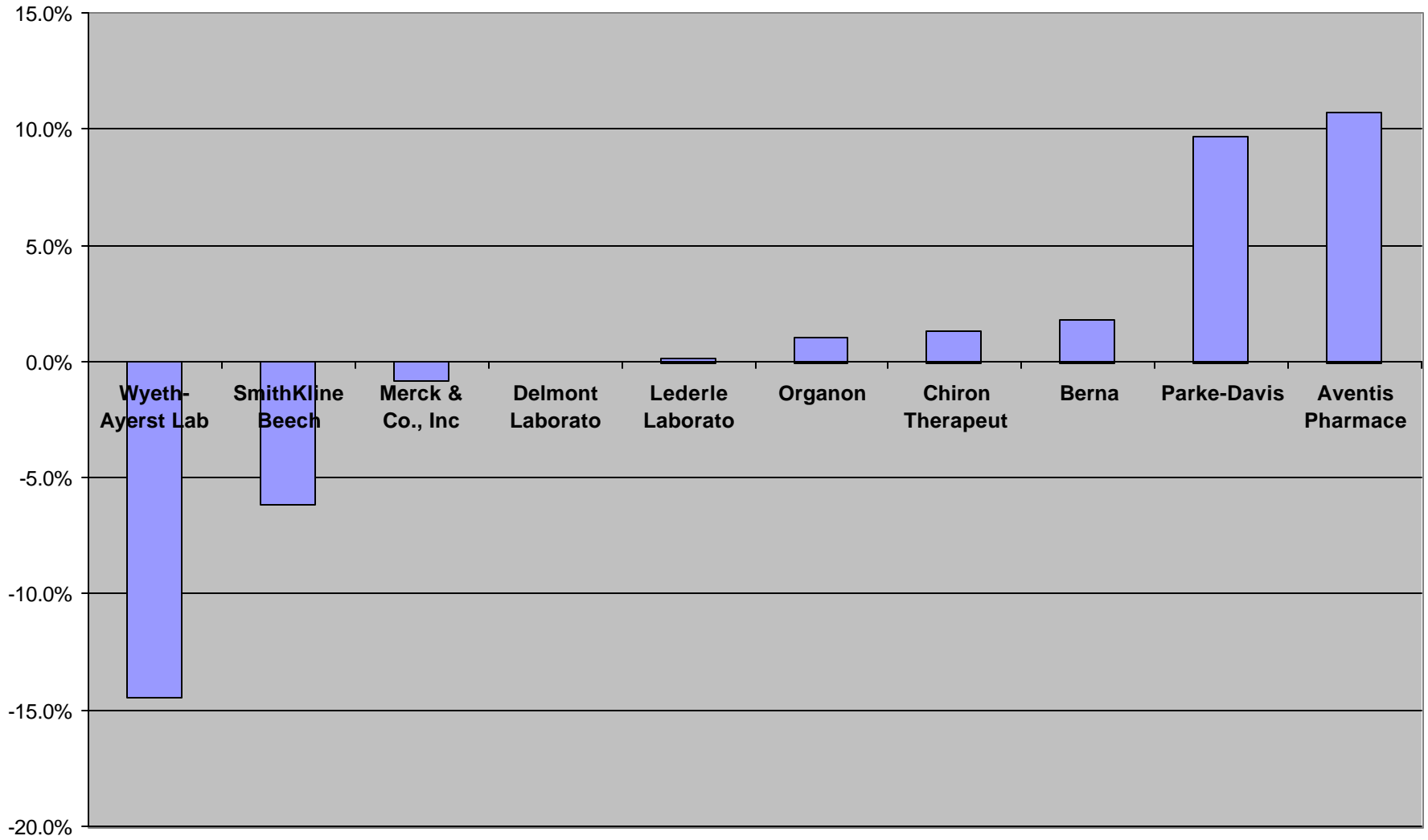
**Figure 1**  
**FSS Vaccine price index (2002 = 1.00)**



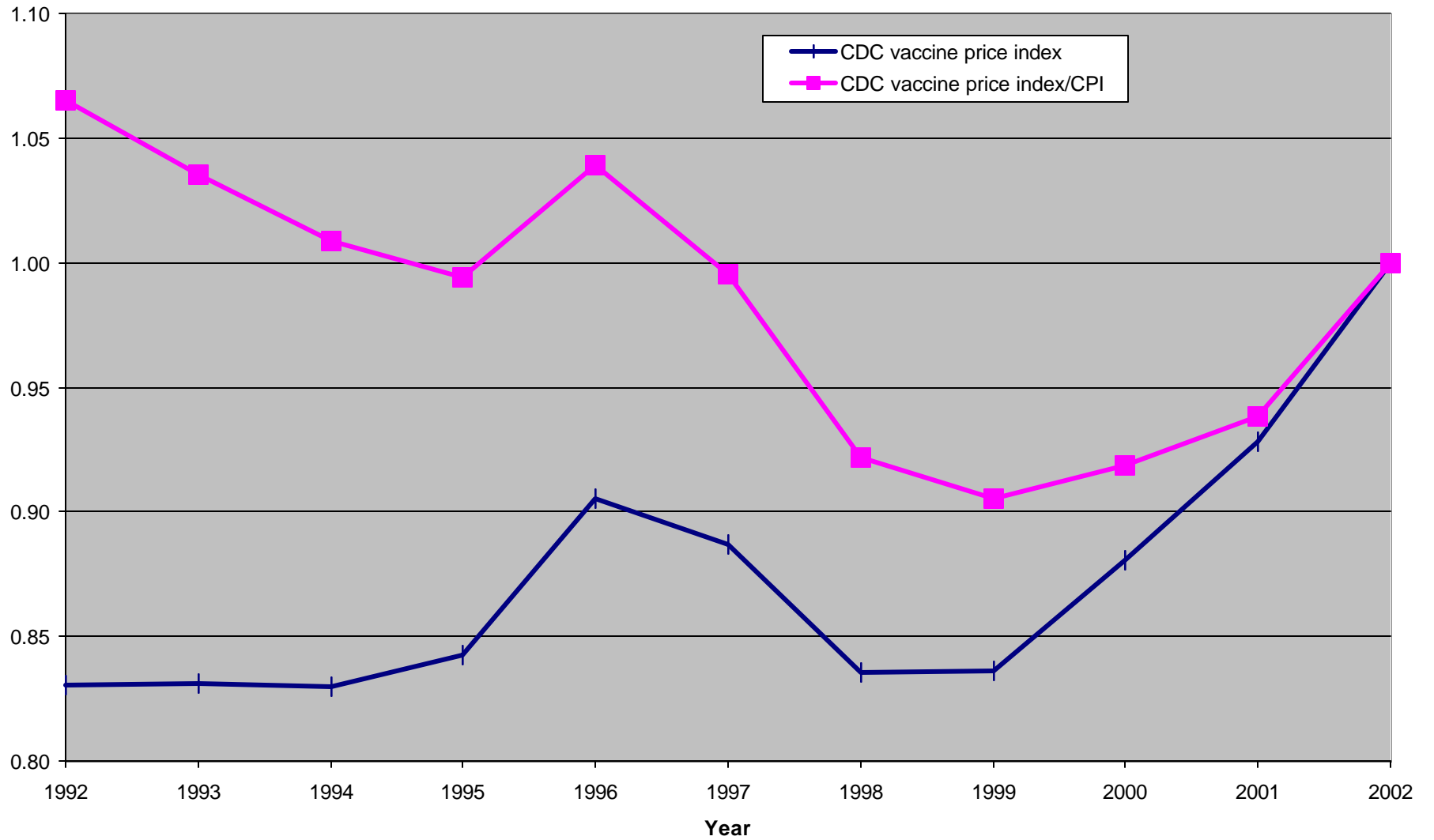
**Figure 2**  
**Increases in FSS vaccine price index and CPI, pre- vs. post-1999**



**Figure 3**  
**Average annual rate of price increase, by source**



**Figure 4**  
**Nominal and real CDC vaccine price indexes, 1992-2002**



**Figure 5**  
**Nominal FSS and CDC vaccine price indexes, 1992-2002**

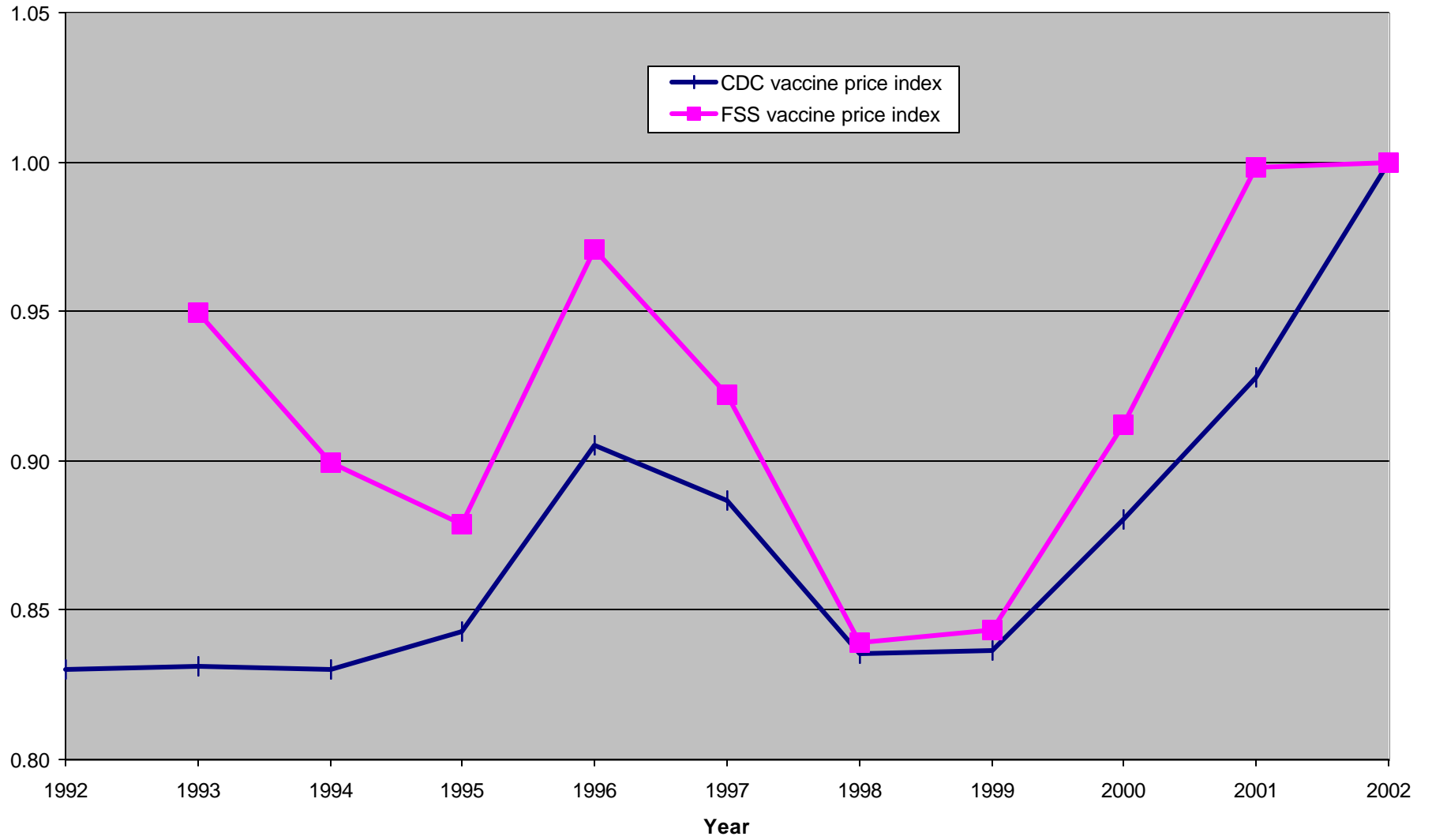


Figure 6

**Figure 6**  
**Average vaccine market HHI (value weighted)**

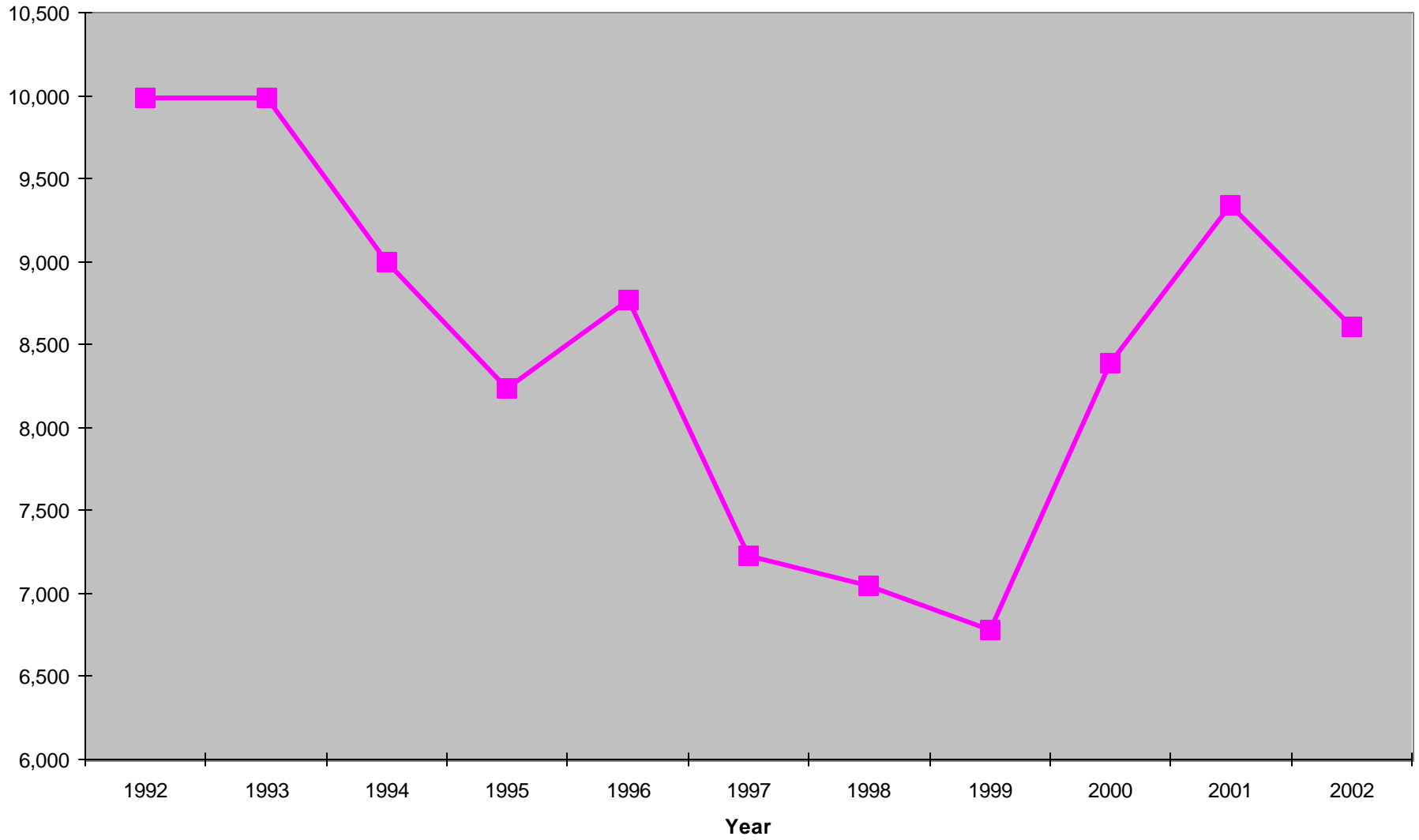


Figure 7

**Figure 7**  
**CDC vaccine price index and average vaccine market HHI**

