

4. Price and quantity data are given as the following.

Year 1

Good	Quantity	Price
Computers	20	\$1,000
Bread	10,000	\$1.00

Year 2

Good	Quantity	Price
Computers	25	\$1,500
Bread	12,000	\$1.10

- a) Year 1 nominal GDP =  $20 \times \$1,000 + 10,000 \times \$1.00 = \$30,000$ .  
Year 2 nominal GDP =  $25 \times \$1,500 + 12,000 \times \$1.10 = \$50,700$ .
- b) With year 1 as the base year, we need to value both years' production at year 1 prices. In the base year, year 1, real GDP equals nominal GDP equals \$30,000. In year 2, we need to value year 2's output at year 1 prices. Year 2 real GDP =  $25 \times \$1,000 + 12,000 \times \$1.00 = \$37,000$ . The percentage change in real GDP equals  $(\$37,000 - \$30,000)/\$30,000 = 22.3\%$ .

We next calculate chain-weighted real GDP. To perform this calculation, we first compute average prices. The average price for computers equals  $(\$1,000 + \$1,500)/2 = \$1,250$ . The average price for bread equals  $(\$1.00 + \$1.10)/2 = \$1.05$ . Year 1 output valued at average prices equals  $20 \times \$1,250 + 10,000 \times \$1.05 = \$35,500$ . Year 2 output valued at average prices equals  $25 \times \$1,250 + 12,000 \times \$1.05 = \$44,850$ . The percentage change in chain-weighted GDP is therefore equal to  $(\$44,850 - \$35,500)/\$35,500 = 26.3\%$ .

- c) To calculate the implicit GDP deflator, we divide nominal GDP by real GDP, and then multiply by 100 to express as an index number. With year 1 as the base year, base year nominal GDP equals base year real GDP, so the base year implicit GDP deflator is 100. For the year 2, the implicit GDP deflator is  $(\$50,700/\$37,000) \times 100 = 137.0$ . The percentage change in the deflator is equal to 37.0%.

With chain weighting, the base year is now the midpoint between the two years. The year 1 GDP deflator equals  $(\$30,000/\$35,500) \times 100 = 84.5$ . The year 2 GDP deflator equals  $(\$50,700/\$44,850) \times 100 = 113.0$ . The percentage change in the chain-weighted deflator equals  $(113.0 - 84.5)/84.5 = 33.7\%$ .

- d) We next consider the possibility that year 2 computers are twice as productive as year 1 computers. As one possibility, let us define a 'computer' as a year 1 computer. In this case, the 25 computers produced in year 2 are the equivalent of

50 year 1 computers. Each year 1 computer now sells for \$750 in year 2. We now revise the original data as:

Year 1

Good	Quantity	Price
Year 1 Computers	20	\$1,000
Bread	10,000	\$1.00

Year 2

Good	Quantity	Price
Year 1 Computers	50	\$750
Bread	12,000	\$1.10

Year 2 real GDP, in year 1 prices is now  $50 \times \$1,000 + 12,000 \times \$1.00 = \$62,000$ . The percentage change in real GDP is equal to  $(\$62,000 - \$30,000)/\$30,000 = 126.7\%$ .

We next revise the value of output at average prices. Chain-weighted year 1 real GDP is equal to  $25 \times \$875 + 12,000 \times \$1.05 = \$34,475$ . Chain-weighted year 2 real GDP is equal to  $50 \times \$875 + 12,000 \times \$1.05 = \$60,725$ . The percentage change in chain-weighted real GDP is therefore equal to  $(\$60,725 - \$34,475)/\$34,475 = 76.1\%$ .

With year 1 as the base year, the year 2 real GDP deflator equals  $(\$50,700/\$62,000) \times 100 = 81.8$ . The percentage rate of change of the deflator equals  $-18.2\%$ .

The chain-weighted deflator for year 1 is now equal to  $(\$30,000/\$34,475) \times 100 = 87.0$ . The chain-weighted deflator for year 2 is now equal to  $(\$50,700/\$60,725) \times 100 = 83.5$ . The percentage change in the GDP deflator is equal to  $(83.5 - 87.0)/87.0 = -4.0\%$ .

When there is no quality change, the difference between using year 1 as the base year and using chain weighting is relatively small. In the case of increased quality, the production of computers rises dramatically while its relative price falls. Chain weighting provides a smaller estimate of the increase in production and a smaller estimate of the reduction in prices. This difference is due to the fact that the relative price of the good that increases most in quantity (computers) is much higher in year 1. Therefore, the use of historical prices puts more weight on the increase in quality-adjusted computer output.