Session 4.2:
Price and Volume Measures

Regional Course on Integrated Economic Statistics to Support 2008 SNA Implementation

Leonidas Akritidis
Office for National Statistics
United Kingdom

Content

1. Introduction
2. Price and Volume: concept and measures
3. Developing relevant deflator
4. Quality change in price indices
5. Price and Volume Indices
6. Chain-linking and re-referencing
7. Double v. Single deflation/extrapolation

1. Introduction:

- Covered in 2008 SNA chapter 15;
- A very useful handbook used in the UK National Accounts and in Europe is the Eurostat Handbook on price and volume measures

1. Introduction

- Uses of price and volumes data:

  Comparing economy over time

  Comparing different economies at the same time

1. Introduction

- Determined by a market
- Non-market products?
- Different types of prices:

  Basic price

  Producer price

  Purchaser price

  Published price indexes (CPI, PPI,)

2. Prices and Volume

Quantity

- Value, price and quantity are linked by the fundamental equation:

$$\boxed{v = p \cdot q}$$

- This equation is valid only for homogeneous products

2. Prices and Volume

Homogeneous products

- Homogeneous products are products for which it is possible to define units which are all considered equivalent and which can thus be exchanged for the same monetary value
- A homogeneous product consists of units of the same quality

2. Prices and Volume

Volumes

- Seems easy when the product is simple - just a physical quantity (one ton of coal or one cup of coffee….)
- But ‘volume’ also includes quality : more “value for money”

- Volume = quantity * quality

2. Prices and Volume

Decomposing values

- Value = Volume x Price

$$Volume = \frac{Value}{Price}$$

- Can also express this as:

- => deflation

2. Prices and Volume

Constant prices

- The notion of volume is introduced to eliminate the effect of price changes on a set of products
- This effect can be offset by calculating what the value of the set of products would have been if there had been no changes in prices

3. Developing relevant deflators

Deflators for market output

- **Best method**: deflation by appropriate producer price indices:
  - basic prices
  - adjustments for quality changes
  - exact correspondence to products to be deflated
  - concepts according to national accounts (or an indicator proven to be equivalent)

3. Developing relevant deflators

Deflators for market output

- **Alternative methods**: less appropriate PPIs, CPIs, volume indicators
- **Unacceptable methods**: input methods, secondary indicators, inappropriate price indices

- To be applied to specific products first

Agriculture

- Usually price*quantity approach so all data are available. Some remaining issues:
  - Production process spread over more than one accounting period
  - Seasonal prices
  - Subsidies

Manufacturing

- Usually PPIs available
- Unique products
  - large equipment: ships, planes, special machines
- Computers

Construction

- Wide range of products
  new construction
  improvements
- Unique products -> model prices
- Production process spread over more than one accounting period

Wholesale and retail trade services

- Trade margins: no direct prices paid for trade services
- Assumption used: volume of output equals volume of sales
- How to measure quality of trade services, eg. supermarket versus shop-on-the corner

Transport and communication

- Transport: passenger-kilometres and tonne-kilometres are acceptable methods
- Take account of subsidies
- “Empty bus” problem
- Communications: differentiate household and business purchases

Banking

- Two parts: explicit charges and FISIM
- For explicit charges price indices can be developed
- This is not the case for FISIM are the use of volume indicators (deleted stock using general price index) and price that is base year interest rates

Non-market services

- Examples - health, education, defense, administration
- Difference between “individual” and “collective” services
- Measurement of output in current prices

Measuring at constant prices?

- Distinguish between:
- Input-based methods - deflating inputs
- Output-based methods - measuring volume of output using indicators

Education

- One definition “quantity of teaching received by students, adjusted to allow for qualities of the services provided, for each type of education”
- What does this mean?
  - Quantity of teaching
  - Adjusted for quality
  - Type of education

Health

- One definition “the quantity of health care received by patients, adjusted to allow for qualities of service provided, for each type of health care”
- Looks similar to education
- What is quantity?

Collective services

- Difficult to define output, but not impossible:
  - Tax system
  - Social Security
  - Public administration?
- Use of activity indicators
- Measuring quality

4. Quality change in price indices

- Examples of quality
- physical characteristics
- accompanying services
- location
- timing
- Price discrimination

4. Quality change in price indices

- Depends on the type of product, but generally:
- Matched models
- Option pricing
- Overlapping
- Expert judgment
- Hedonics

5. Price and Volume indices

Comparing base and current periods

- The value of a set of products in the current period is:

$$\boxed{v^1 = \sum_i p_i^1 \times q_i^1}$$

$$\boxed{Vol = \sum_i p_i^0 \times q_i^1}$$

- The volume can be defined as:

- The volume index is:

$$\boxed{IVol = \frac{\sum_i p_i^0 \times q_i^1}{\sum_i p_i^0 \times q_i^0}}$$

5. Price and Volume indices

Table 1 Car Production

	Year 0			Year 1			
	Price (000 $/un.)	Quantity (No.)	Value (000 $)	Price (000 $/un.)	Quantity (No.)	Value (000 $)	Value (year 0 $)
	(1)	(2)	(3) = (1)*(2)	(4)	(5)	(6)=(4)*(5)	(7)=(1)*(5)
Model A	20	15	300	40	24	960	480
Model B	10	15	150	20	6	120	60
Σ		30	450		30	1,080	540

Values in column (6) are in current prices showing a 140 percent increase over year 0 (index = 1080/450 = 240)

Values in column (7) are at constant prices of year 0, they reflect changes in quantity and/or quality.

➢Values at constant prices are an aggregated volume measure, expressed in money terms and additive

5. Price and Volume indices

- The average of the proportionate changes in the price (or volume) of a specific set of goods and services between two periods of time

5. Price and Volume indices

The Laspeyres philosophy

- time periods 0 and t
- quantity (volume) relatives qt/q0
- weights : share in total value of period 0
- Laspeyres volume index

  (arithmetic mean of quantity relatives)

$$L_q = \sum \frac{v_0 \, q_t / q_0}{\sum v_0} = \frac{\sum p_0 q_t}{\sum p_0 q_0}$$

5. Price and Volume indices

The Laspeyres philosophy

- time periods 0 and t
- price relatives pt/p0
- weights of period 0
- Laspeyres price index

$$L_P = \sum \frac{v_0 \, p_t / p_0}{\sum v_0} = \frac{\sum p_t q_0}{\sum p_0 q_0}$$

5. Price and Volume indices

Laspeyres Volume Index Formula

- The change from the base year in constant prices or the ratio of the current year volume to the base year volume in table 1 may be expressed in index form as:

  $LQ_{0\to t}$ = 540 x 100 / 450 = 120.0
- This is also called Laspeyres (fixed-base) volume index ($LQ_{0\to t}$).
- Mathematically:

$$LQ_{0\to t} = Q_{0,t} / Q_{0,0} = Q_{0,t} / V_0 = \sum_i p_{i,0} \times q_{i,t} \Big/ \sum_i p_{i,0} \times q_{i,0} \qquad (1)$$

- Note: the two components of the index are ADDITIVE
- The Laspeyres volume index can also be written as:

$$LQ_{0\to t} = \sum_i w_{i,0} \times q_{i,t} / q_{i,0} \qquad (2)$$

  - where $w_{i,o}$ is the base period weight, i.e. the items share in the total value in the base period

5. Price and Volume indices

The Laspeyres philosophy

Table 2

	Year 0				Year 1		
	Price (000 $/un.)	Quantity (No.)	Value (000 $)	Weight (w_0)	Quantity (No.)	Quantity relatives (QR)	W_0*QR
	(1)	(2)	(3) = (1)*(2)	(4)=(3)/Σ(3)	(5)	(6)=(5)/(2)	(7)=(4)*(6)*100
Model A	20	15	300	66.7%	24	1.6	107
Model B	10	15	150	33.3%	6	0.4	13
Σ		30	450		30		120

Paasche Price Index Formula

- To factor the change in the value of car production from year 0 to year 1 arising from **price** changes.
  - take the ratio of the value of output in current prices in year 1 to the value of output in year 1 measured in constant prices (prices of year 0) (and multiply it with 100 to convert to an index form):

$PP_{0\rightarrow t}$ = 1080 x 100 / 540 = 200.0

Shows 100 percent increase or doubling in prices

The above ratio is also called the Paasche price index ($PP_{0\rightarrow t}$). Algebraically:

$$PP_{0\rightarrow t} = V_t \big/ Q_{0,t} = \sum_i p_{i,t} \times q_{i,t} \Big/ \sum_i p_{i,0} \times q_{i,t} \qquad (1)$$

or

$$PP_{0\rightarrow t} = 1 \Big/ \sum_i w_{i,t} \times p_{i,0} \big/ p_{i,t} \qquad (2)$$

where $w_{i,t}$ is the current period weight, i.e. the items share in the total value in the current period

Paasche Price Index Formula

According to the later formulation, $PP_{0\rightarrow t}$ is derived as follows from the data in table 1:

Table 3

	Year 0	Year 1				
	Price (000 \$/un.)	Price (000 \$/un.)	Value (000 \$)	Weight (w_1)	Price relatives (PR)	w_1*PR
	(1)	(2)	(3)	(4)=(3)/Σ(3)	(5)=(1)/(2)	(6)=(4)*(5)*100
Model A	20	40	960	88.9%	0.5	0.44
Model B	10	20	120	11.1%	0.5	0.06
Σ			1,080			0.50
$PP_{0\rightarrow t} = 1/\Sigma(w_1 * PR) = (1/0.5) \times 100$						200.00

- The ratio of any aggregate in current prices to the aggregate in constant prices yields an implicit Paasche price deflator
- Price measures for the main national accounts aggregates are (always) derived implicitly

5. Price and Volume indices

Value, Volume and Price Indexes

The change in the current price value of car production from year 0 to year 1 in our example can be expressed algebraically as:

$$V_t / V_0 = \sum_i p_{i,t} q_{i,t} \Big/ \sum_i p_{i,0} q_{i,0}$$

Multiplying and dividing by $\Sigma_i\, p_{i,0} q_{i,t}$ gives:

$$V_t / V_0 = \left(\sum_i p_{i,0} q_{i,t} \Big/ \sum_i p_{i,0} q_{i,0}\right) * \left(\sum_i p_{i,t} q_{i,t} \Big/ \sum_i p_{i,0} q_{i,t}\right)$$

Value index = Laspeyres Volume index * Paasche Price index / 100

$$\underbrace{V_t / V_0 \times 100}_{240} = \underbrace{LQ_{0\to t}}_{120} \times \underbrace{PP_{0\to t}}_{200} / 100$$

- The volume and price effects of value change are multiplicative
- When V_t and V_0 are known and $PP_{0\to t}$ is available the Laspeyres volume index can be derived indirectly from above formula – a process called price deflation

5. Price and Volume indices

Value, Volume and Price Indexes

Another set of volume and price indices may be obtained starting from the change in the current price value of car production from year 0 to year 1:

$$V_t / V_0 = \sum_i p_{i,t} q_{i,t} \Big/ \sum_i p_{i,0} q_{i,0}$$

Multiplying and dividing by $\Sigma_i\, p_{i,t} q_{i,0}$ gives:

$$V_t / V_0 = \left(\sum_i p_{i,t} q_{i,o} \Big/ \sum_i p_{i,0} q_{i,0}\right) * \left(\sum_i p_{i,t} q_{i,t} \Big/ \sum_i p_{i,t} q_{i,0}\right)$$

or Value index = Paasche Volume index * Laspeyres Price index / 100

$$\underbrace{V_t / V_0 \times 100}_{240} = \underbrace{LP_{0\to t}}_{200} \times \underbrace{PQ_{0\to t}}_{120} / 100$$

- $PQ_{0\to t}$ can be obtained by inflating the base period values using the often available $LP_{0\to t}$ and then dividing the current price value by this amount.

5. Price and Volume indices

Laspeyres, Paasche and Fischer

- Laspeyres: weights of period 0
- Paasche: weights of period t
- Fischer: geometric mean of Laspeyres and Paasche

5. Price and Volume indices

Laspeyres, Paasche and Fischer

Value index

=

Laspeyres volume index * Paasche price index

=

Paasche volume index * Laspeyres price index

=

Fischer volume index * Fischer price index

Example

• Value in 2005:	120
• Paasche price index 2004-2005:	125
• Volume 2005 in prices of 2004:	96
• Laspeyres volume index 2004-2005:	120
• Value in 2004:	80

- Value change = 20% * 25% = 50%

5. Price and Volume indices

- CPIs, PPIs: all Laspeyres price indices
- Define precise bundle of goods and services & obtain their value shares in base year (for weighting)
- Observe monthly prices, by going to shops, magazines, internet, etc.
- Calculate index

6. Chain-linking and re-referencing

- When a fixed base Laspeyres is used over a long run of periods, the weights become progressively out of date and irrelevant.
- **Chain-linking** is simply the limiting case in which the weights are updated each period.
- No fixed base year but moving base year: always use weights of previous year to calculate growth rates (Previous Year Prices - PYPs)
- Chain year-on-year growth rates together to obtain "constant price" data
- Non - additivity will occur in "constant price" series

6. Chain-linking and re-referencing

Base and reference period

- Base period

  the period that provides the weights for the index

- Reference period

  the period for which the index has the value 100

6. Chain-linking and re-referencing

Re-Referencing

Table 6

	2000	2005	2010	2011
Index (reference period 2000=100)	100	110	120	130
Growth rate *(percent)*		*10.0*	*9.1*	*8.3*
New Index (reference period 2010=100)	83.3 (100/120)	91.7 (110/120)	100 (120/120)	108.3 (130/120)
Growth rate *(percent)*		*10.1*	*9.1*	*8.3*

Note:

- Growth rate remains the same
- Re-referencing shifts focus to new reference year
- Values of the other periods are now compared with the value in this year

6.Change of Base Year. Effect on growth rates

Table 7

	2000	2005	2010	2011	Growth rate (percent) 2000-05	2005-10	2010-11
Values in current prices							
Wool							
Price	5	10	20	22	*100.0*	*100.0*	*10.0*
Quantity	4	5	6	7	*25.0*	*20.0*	*16.7*
Value	20	50	120	154	*150.0*	*140.0*	*28.3*
Mutton							
Price	15	10	5	4	*-33.3*	*-50.0*	*-20.0*
Quantity	11	10	8	7	*-9.1*	*-20.0*	*-12.5*
Value	165	100	40	28	*-39.4*	*-60.0*	*-30.0*
TOTAL							
Value	**185**	**150**	**160**	**182**	***-18.9***	***6.7***	***13.8***
Values in constant prices of 2000							
Wool	20	25	30	35	*25.0*	*20.0*	*16.7*
Mutton	165	150	120	105	*-9.1*	*-20.0*	*-12.5*
TOTAL	**185**	**175**	**150**	**140**	***-5.4***	***-14.3***	***-6.7***
Values in constant prices of 2005							
Wool		50	60	70		*20.0*	*16.7*
Mutton		100	80	70		*-20.0*	*-12.5*
TOTAL		**150**	**140**	**140**		***-6.7***	***0.0***
Values in constant prices of 2010							
Wool			120	140			*16.7*
Mutton			40	35			*-12.5*
TOTAL			**160**	**175**			***9.4***

7. Double v. Single deflation/extrapolation

Best method: double deflation/extrapolation

- GVA is derived as output less intermediate consumption at constant prices, both obtained separately

Alternative method:

Single extrapolation

- GVA is extrapolated using output data
- GVA is extrapolated using employment data

Single deflation

- GVA is deflated using output deflator
- GVA is deflated using the wage index
- GVA is deflated using a general price index, e.g. CPI

7. Illustration of Double Deflation Method

Double Deflation – Example

	2003							
	Current prices			Price indexes		Constant (2000) prices		
	GO (000 $)	IC (000 $)	GVA (000 $)	PPI (2000=100)	ICI (2000=100)	GO (000 $)	IC (000 $)	GVA (000 $)
	(1)	(2)	(3)=(1)-(2)	(4)	(5)	(6)=(1)/(4)*100	(7)/(5)*100	(8)=(6)-(7)
Mining	7,300.0	3,800.0	3,500.0	210.0	215.0	3,476.2	1,767.4	1,708.7
Manufacturing	12,800.0	6,300.0	6,500.0	185.0	206.0	6,918.9	3,058.3	3,860.7
Total	**20,100.0**	**10,100.0**	**10,000.0**	----	----	**10,395.1**	**4,825.7**	**5,569.4**

	2000 Current prices	2003	
	GVA (000 $)	GVA volume index (2000=100)	GVA implicit deflator (2000=100)
	(9)	(10)=(8)/(9)*100	(11)=(3)/(8)*100
Mining	1,735.0	98.5	204.8
Manufacturing	3,680.0	104.9	168.4
Total	**5,415.0**	**102.9**	**179.6**

GO: Gross Output
IC: Intermediate Consumption
GVA: Gross Value Added
PPI: Producer Price Index
ICI: Intermediate Consumption price Index

7. Illustration of Single Indicator Methods

Primary data

Date	Output at current prices (1)	Intermediate consumption current . (2)	Value added current prices (3)=(1)-(2)
2000	3,200	2,400	800
2001	2,940	2,100	840
2001	3,680	2,700	980

Date	Output at constant 2000 prices (4)	Paasche price deflator for output (5)=(1)/(4)*100	Output volume index (6)=(4) / 3200 * 100
2000	3,200	100.0	100.0
2001	3,000	98.0	93.8
2002	3,100	118.7	96.9

7. Illustration of Single Indicator Methods

Single extrapolation

Date	Value added 2000	Laspeyres volume index output (6)			Value added constant 2000 prices (7)=800*(6) / 100
2000	800	100.0	800*1.000	=	800.0
2001	......	93.8	800*0.938	=	750.0
2002	......	96.9	800*0.969	=	775.0

Single deflation

Date	Paasche price deflator for output (5)	Value added current prices (13)=(1)-(2)			Value added constant 2000 prices (14)=(13)/(5) * 100
2000	100.0	800.0	800/1.000	=	800.0
2001	98.0	840.0	840/0.980	=	857.1
2002	118.7	980.0	980/1.187	=	825.5