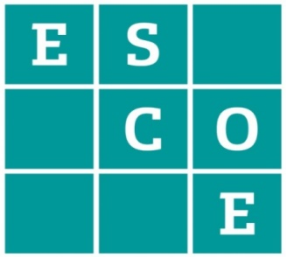

ECONOMIC STATISTICS CENTRE OF EXCELLENCE

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Office for National Statistics

ESCoE Research Seminar

Double Deflation: Theory and Practice

Presented by Nicholas Oulton, London School of Economics

27 February 2018

Double Deflation
Theory and Practice

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ECONOMIC STATISTICS CENTRE OF EXCELLENCE

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ROADMAP

- Double deflation versus single deflation: basic motivation and concepts
- How the ONS estimates GDP at the moment using single deflation
- How double deflation can be implemented in the framework of the Supply Use Tables (SUTs)
- Doing it properly: the challenges ahead.

Double deflation: why bother?

- Real GDP can be calculated either from the expenditure side or from the output side. *In principle*, i.e. in the absence of errors and omissions, we want the two calculations to give the same answer.
- It has been known for a long time that this is *not* the case under single deflation. Only double deflation can guarantee that this is the case.

Double deflation and the national accounts

- To calculate real GDP from the output side, GDP(O), the ONS has to calculate real value added in each industry.
- “Single deflation” is shorthand for the way in which the ONS calculates real value added at the moment.
- “Double deflation” is shorthand for a different way of calculating real value added. It is the method recommended in the most recent System of National Accounts (SNA 2008) and is mandated by Eurostat (ESA 2010). Also recommended by the Bean Review (2016).
- 10 of the G20 countries already use double deflation (Alexander et al. 2017).
- The ONS is committed to switching over to double deflation (Daniel et al. 2017).

Advantages of double deflation

- Greater coherence in the national accounts: growth of real GDP(O) = growth of real GDP(E)
- Better estimates of real value added at the industry level. E.g. under single deflation the effects of outsourcing on productivity are hard to trace.
- Better measures of labour productivity and TFP growth at the industry level. Implementing double deflation enables us to measure productivity better. So we are better able to see what is happening to innovation at the industry level (Oulton 2016).

Double deflation: the issues

- Will the new estimates of real value added at the industry level tell a very different story from the present ones?
- Will they be implausible, maybe because they are too volatile?
- Will double deflation change the past by generating a very different path for real GDP?
- Could double deflation even make the productivity puzzle disappear?

Basic national income accounting relationships

In *current* (basic) prices, GDP can be measured from the output, expenditure or income sides:

- GDP(E) = C + I + G + X – M = TFE minus imports
- GDP(O) = Sum across industries of value added
- GDP(I) = Labour income + Gross operating surplus
- And GDP(O) = GDP(E) = GDP(I)

These relationships are true *by definition*. If they are not true in practice, we know that there must be errors or omissions in the underlying data.

GDP in real terms

- In real terms, there is just GDP(O) and GDP(E) to consider. There is no independent measure of real GDP(I).
- Since GDP(O) = GDP(E) in *current* prices, surely this should also be the case in real terms?
- That is, we surely want that

Growth of real GDP(O) = Growth of real GDP(E)

in principle, i.e. in the absence of errors and omissions.

- If this is not the case, there would be two different measures of economic growth, *even with perfect data*. This would make no sense.

The growth of real GDP(E)

In the UK real growth is measured by a chained Laspeyres index. So

$$\text{Growth of GDP}\left(\text{E}\right) \text{ between } t\text{-}1 \text{ and } t = \sum_i s_{i,t-1}\left(\frac{E_{it}}{E_{it-1}}\right)$$

E_{it} : i-th component of final demand, real, in year t

$s_{i,t-1}$: share of i-th component in nominal GDP in year t-1

i.e. it is a weighted average of the growth rates of the components, where the weights are the shares of each component in GDP in the previous year.

The growth of real GDP(O)

Analogously, for the growth of real GDP(O) :

Growth of GDP$\left(\mathrm{O}\right)$ between t-1 and $t = \sum_i v_{i,t-1}\left(\frac{V_{it}}{V_{i,t-1}}\right)$

V_{it} : Real value added in i-th industry in year t

$v_{i,t-1}$: share of value added in i-th industry in nominal GDP in year t-1

i.e. a weighted average of the growth rates of real value added, where the weights are the shares of each industry's value added in nominal GDP in the previous year.

Real value added: single deflation

Currently, the ONS measures real value added by single deflation. The growth rate of real value added is set equal to the growth rate of real gross output:

$$\frac{V_{it}^{SD}}{V_{i,t-1}^{SD}} = \frac{Y_{it}}{Y_{i,t-1}}$$

Y_{it} : Real gross output, i.e. nominal gross output deflated by an appropriate price index

This is simple to calculate. But it does *not* assure that growth of GDP(O) = growth of GDP(E).

Real value added: double deflation

Under double deflation, output is deflated separately from the inputs:

$$\left(\frac{V_{it}^{DD}}{V_{i,t-1}^{DD}}\right)=\frac{1}{v_{i,t-1}}\left[\left(\frac{Y_{it}}{Y_{i,t-1}}\right)-\sum_j w_{ij,t-1}\left(\frac{X_{ijt}}{X_{ij,t-1}}\right)\right]$$

V_{it}^{DD} : double-deflated real value added in i-th industry

X_{ijt} : j-th intermediate input into i-th industry, real

$v_{i,t-1}$: share of value addded in nominal gross output in t-1

$w_{ij,t-1}$: share of j-th intermediate input in nominal gross output in t-1

This is harder to calculate since knowledge of input-output coefficients is required as well as price indices for all inputs.

[Note: real value added could be negative on the Laspeyres approach]

Double deflation versus single deflation

- Single deflation produces the same answer as double deflation if and only if the cost-weighted average growth rate of the real inputs equals the growth rate of real gross output.
- Single deflation is easier to do. BUT:
- Single deflation does *not* ensure that growth of real GDP(O) = growth of real GDP(E).
- Double deflation does ensure this equality *provided* that the price indices are “consistent” (discussed later).

So how does this work in the UK?

- In practice, GDP(E) is paramount. The ONS adjusts the growth of GDP(O) so that it equals that of GDP(E) to within a small tolerance (0.1 % pa)
- They do this through “coherence adjustments” which are applied to the estimates of real value added in private services. No adjustments are made to government output or to the production sector.
- These coherence adjustments are not usually published (Lee 2011).
- Why is GDP(E) paramount? Answer: the price indices are more reliable than on the output side. (E.g. the CPI covers two thirds of GDP(E))

There is more than one way in which double deflation could be implemented in practice.

To understand these different ways we need to use the framework of the Supply and Use Tables (SUTs)

Supply Use Tables (SUTs)

- The framework within which the national accounts are constructed.
- *N* products and *N* industries. Tables are *N*x*N*.
- Each industry is defined by its “principal product”. E.g. the Agriculture industry produces Agriculture products, but maybe other products too.
- SUTs are estimated in current prices (CP). For double deflation they must be estimated also in previous year’s prices (PYP).

Supply Table

- The Supply Table shows the sales by each of the *N* industries of each of the *N* products, also imports of each of the *N* products.
- Total supply of each product = domestic supply + imports.
- Total output of each industry = its sales of all products

Supply table (expanded), current basic prices

		Domestic output				Imports	Total supply
	Product/ industry	(1)	(2)	⌞	(*N*)		(row total)
Sales	(1)	Y_{11}	Y_{12}	⌞	Y_{1N}	M_1^{all}	$\sum_{j=1}^{N} Y_{1j} + M_1^{all}$
	(2)	Y_{21}	Y_{22}	⌞	Y_{2N}	M_2^{all}	$\sum_{j=1}^{N} Y_{2j} + M_2^{all}$
	⌞	⌞	⌞	O	⌞	⌞	⌞
	(*N*)	Y_{N1}	Y_{N2}	⌞	Y_{NN}	M_N^{all}	$\sum_{j=1}^{N} Y_{Nj} + M_N^{all}$
Column total	Gross output	$GO_1 \left[= \sum_i Y_{i1} \right]$	$GO_2 \left[= \sum_i Y_{i2} \right]$	⌞	$GO_N \left[= \sum_i Y_{iN} \right]$	$M^{all} \left[= \sum_i M_i^{all} \right]$	$\sum_{j=1}^{N} GO_j + M^{all}$

The supply table shows sales (*Y)* of product *i* by industry *j*,
also imports (*M)* of product *i*.
Row total: total supply of each product
Column total: gross output of each industry
Published table shows only total sales by domestic industries.

Use Table

- The Use Table shows the purchases by each industry of each product (intermediate consumption), and final demand for each product. It also shows purchases by each industry of labour and capital services.
- Row totals: total demand (use), final + intermediate, of each product.
- Column totals: total purchases by each industry.

Use table (expanded), in current basic prices

		Intermediate purchases				*Total intermediate*	Final demand	*Total demand for products*
Product/ industry		(1)	(2)	…	(*N*)			*(row total)*
Sales by domestic industries	(1)	X_{11}	X_{12}	…	X_{1N}	$\sum_{j=1}^{N} X_{1j}$	F_1	$\sum_{j=1}^{N} X_{1j} + F_1$
	(2)	X_{21}	X_{22}	…	X_{2N}	$\sum_{j=1}^{N} X_{2j}$	F_2	$\sum_{j=1}^{N} X_{2j} + F_2$
	…	…	…	…	…	…	…	…
	(*N*)	X_{N1}	X_{N2}	…	X_{NN}	$\sum_{j=1}^{N} X_{Nj}$	F_N	$\sum_{j=1}^{N} X_{Nj} + F_N$
Sales of imports	(1)	M_{11}	M_{12}	…	M_{1N}	$\sum_{j=1}^{N} M_{1j}$	M_1^{FD}	M_1^{all}
	(2)	M_{21}	M_{22}	…	M_{2N}	$\sum_{j=1}^{N} M_{2j}$	M_2^{FD}	M_2^{all}
	…	…	…	…	…	…	…	…
	(*N*)	M_{N1}	M_{N2}	…	M_{NN}	$\sum_{j=1}^{N} M_{Nj}$	M_N^{FD}	M_N^{all}
IC		$\sum_{i=1}^{N}\left[X_{i1} + M_{i1}\right]$	$\sum_{i=1}^{N}\left[X_{i1} + M_{i1}\right]$	…	$\sum_{i=1}^{N}\left[X_{i1} + M_{i1}\right]$	$\sum_{i=1}^{N}\sum_{j=1}^{N}\left[X_{ij} + M_{ij}\right]$	$\sum_{i=1}^{N}\left[M_i^{FD} + F_i\right]$	$\sum_{i=1}^{N}\left[M_i^{all} + F_i + \sum_{j=1}^{N} X_{ij}\right]$
	Value added	VA_1	VA_2	…	VA_N	$\sum_{j=1}^{N} VA_j$	–	–
Column total	Gross output	GO_1	GO_2	…	GO_N	$\sum_{j=1}^{N} GO_j$	–	–

Use table shows purchases by industry *j* of product *i*. also purchases of labour and capital services. Published table combines imports and domestic supplies.

Links between supply and use tables

- For each of the *N products*,

  total supply = total use

That is, each *row* total of the supply table = the corresponding *row* total of the use table.

- For each of the *N industries*,

  total sales = total purchases

That is, each *column* total of the supply table = the corresponding column total of the use table.

Supply-use balancing

- These equalities result from the accounting principle that to every sale there corresponds a purchase.
- But in practice they don’t happen automatically since the underlying data come from different sources.
- They have to be brought about by the supply-use balancing process.

Links with GDP and the national accounts

- From the SUTs, we can calculate GDP:

  GDP(O) at current basic prices = Sum across industries of value added

  GDP(E) at current basic prices = Sum of final demands for domestic output *less* intermediate imports

- And it can be proved that GDP(O) = GDP(E) provided that the tables are balanced.

Supply-use tables at previous year's prices (PYP)

- To implement double deflation in the chained Laspeyres framework, each element in the supply and use tables must be revalued to PYP. I.e., each element in the CP tables must be multiplied by the price in year *t*-1 relative to the price in year *t*.
- Question: if this is done, will the tables at PYP continue to balance?
- Answer: only if the price indices are "consistent".
- Why does this matter? Only if GDP(O) = GDP(E) at PYP as well as in CP will the growth rate of the two measures be equal.

Consider again the supply table at CP …

Supply table (expanded), current basic prices

		Domestic output				Imports	Total supply
	Product/ industry	(1)	(2)	⌞	(*N*)		(row total)
Sales	(1)	Y_{11}	Y_{12}	⌞	Y_{1N}	M_1^{all}	$\sum_{j=1}^{N} Y_{1j} + M_1^{all}$
	(2)	Y_{21}	Y_{22}	⌞	Y_{2N}	M_2^{all}	$\sum_{j=1}^{N} Y_{2j} + M_2^{all}$
	⌞	⌞	⌞	O	⌞	⌞	⌞
	(*N*)	Y_{N1}	Y_{N2}	⌞	Y_{NN}	M_N^{all}	$\sum_{j=1}^{N} Y_{Nj} + M_N^{all}$
Column total	Gross output	$GO_1 \left[= \sum_i Y_{i1} \right]$	$GO_2 \left[= \sum_i Y_{i2} \right]$	⌞	$GO_N \left[= \sum_i Y_{iN} \right]$	$M^{all} \left[= \sum_i M_i^{all} \right]$	$\sum_{j=1}^{N} GO_j + M^{all}$

The supply table shows sales (*Y)* of product *i* by industry *j*,
also imports (*M)* of product *i*.
Row total: total supply of each product
Column total: gross output of each industry
Published table shows only total sales by domestic industries.

Now consider the same table revalued to PYP.

Here we use just two sets of prices, one for domestically-produced outputs and the other for imports.

Domestic (foreign) firms are assumed to sell a given product at the same price to all buyers.

Supply table at PYP (simplified): two sets of prices

		Domestic output				Imports	Total supply
	Product/ industry	(1)	(2)	⌞	(*N*)		(row total)
Sales	(1)	$P_1^Y Y_{11}$	$P_1^Y Y_{12}$	⌞	$P_1^Y Y_{1N}$	$P_1^M M_1^{all}$	$P_1^Y \sum_{j=1}^{N} Y_{1j} + P_1^M M_1^{all}$
	(2)	$P_2^Y Y_{21}$	$P_2^Y Y_{22}$	⌞	$P_2^Y Y_{2N}$	$P_2^M M_2^{all}$	$P_2^Y \sum_{j=1}^{N} Y_{2j} + P_2^M M_2^{all}$
	⌞	⌞	⌞	○	⌞	⌞	⌞
	(*N*)	$P_N^Y Y_{N1}$	$P_N^Y Y_{N2}$	⌞	$P_N^Y Y_{NN}$	$P_N^M M_N^{all}$	$P_N^Y \sum_{j=1}^{N} Y_{Nj} + P_N^M M_N^{all}$
Column total	Gross output	$\bar{P}_1^Y GO_1 \left[= \sum_i P_i^Y Y_{i1} \right]$	$\bar{P}_2^Y GO_2 \left[= \sum_i P_i^Y Y_{i2} \right]$	⌞	$\bar{P}_N^Y GO_N \left[= \sum_i P_i^Y Y_{iN} \right]$	$\bar{P}^M M^{all} \left[= \sum_i P_i^M M_i^{all} \right]$	$\sum_{j=1}^{N} \bar{P}_j^Y GO_j + \bar{P}^M M^{all}$

P_j^Y : price at which domestic producers sell product *j*

P_j^M : price at which foreign producers sell product *j*

Consistency of price indices

Consider a single row of the use table at CP:

$$S_{it} = IC_{it} + C_{it} + I_{it} + G_{it} + EX_{it}, \quad i = 1, 2, ..., N$$

S_{it} : total supply; IC_{it} : intermediate consumption

C_{it} : household consumption; I_{it} : investment

G_{it} : government spending; EX_{it} : exports

Suppose that for each product there is just one price for all users. Then revaluing at PYP:

$$P_{i,t-1}S_{it} = P_{i,t-1}\left[IC_{it} + C_{it} + I_{it} + G_{it} + EX_{it}\right], \quad i = 1, 2, ..., N$$

So the table continues to be balanced at PYP.

A more realistic case

But this is unrealistic. So let each use has its own price. Then at PYP the *i*-th row of the use table is

$$P^{S}_{i,t-1} \cdot S_{it} = P^{IC}_{i,t-1} \cdot IC_{it} + P^{C}_{i,t-1} \cdot C_{it} + P^{I}_{i,t-1} \cdot I_{it} + P^{G}_{i,t-1} \cdot G_{it} + P^{EX}_{i,t-1} \cdot EX_{it}$$

But if these 6 price indices are all picked independently of each other, then there is no reason to expect this equation to hold.

One way to ensure balance is if the supply price on the left hand side is made a weighted average of the prices on the right hand side:

$$P^{S}_{i,t-1} = \left(\frac{IC_{it}}{S_{it}}\right) P^{IC}_{i,t-1} + \left(\frac{C_{it}}{S_{it}}\right) P^{C}_{i,t-1} + \left(\frac{I_{it}}{S_{it}}\right) P^{I}_{i,t-1} + \left(\frac{G_{it}}{S_{it}}\right) P^{G}_{i,t-1} + \left(\frac{EX_{it}}{S_{it}}\right) P^{EX}_{i,t-1}$$

Price indices available in practice

- In practice the ONS collects 5 sets of price indices:
  1. Producer Price Indices (PPIs) (basic prices)
  2. Services Producer Price Indices (SPPIs) (basic prices)
  3. Export price indices (EPIs) (basic prices)
  4. Import price indices (IPIs) (basic prices)
  5. Consumer price indices (CPIs) (purchasers' prices)

- So how shall we choose which prices to use for double deflation?

Two ways of doing double deflation

- Case A: PPIs (or SPPIs) applied to all uses except EPIs are assigned to exports. IPIs assigned to imports.

- Case B: PPIs (or SPPIs) used for intermediate sales and for investment; EPIs used for exports; CPIs (adjusted for taxes, margins and imports) used for consumption. IPIs assigned to imports.

Two ways of doing double deflation

- Case A: PPIs (or SPPIs) applied to all uses except EPIs assigned to exports

Case A is close to current GDP(O) methodology. But it would produce different estimates of GDP from the current methodology. I.e. it will change the past.

- Case B: PPIs used for intermediate sales and for investment; EPIs used for exports; CPIs (adjusted for taxes, margins and imports) used for consumption.

Case B should produce the same estimates of GDP as the current methodology. But there may still be inconsistencies between PPIs and CPIs (even after adjusting for taxes, margins and imports).

Preliminary findings

- Initial findings based on a simple methodology similar to Case A suggest that the slowdown in productivity growth in Information and Communication may be less significant when we take into account differential input and output prices in calculating GVA. (Riley et al. 2017).
- Initial findings also suggest that the volatility of growth is significantly higher under double deflation.

Implementing double deflation is challenging!

- There are issues of consistency between different price indices (e.g. CPIs and PPIs). If we strip out imports, margins and taxes from the CPI for widgets, will it be close to the PPI for widgets? If not, which one should we use?
- The SUTS have to be expanded to split imports from domestically-supplied inputs. This is difficult given there has been no Purchases Inquiry in recent years.
- Doing double deflation properly amounts to a stress test of the whole national accounts system. If the industry estimates seem implausible, one might want to revisit the supply-use balancing process.
- So there is plenty of work still to do and we are not able yet to answer definitively the questions posed earlier.

Conclusions

- Double deflation might change the past but it doesn't have to. It all depends on how it is implemented. One way (Case B above) would leave real GDP unchanged.
- But double deflation will still change the growth path of individual industries. A preliminary analysis (similar to Case A above) suggests this could be quite significant, also that industry growth rates become more volatile.
- A lot more work is still needed. In particular we need to estimate expanded SUTs in each year. These will be at basic prices and will split domestic supply from imports.
- Watch out for "Double deflation: Part II"!

THE END

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