FEATURE

Measures of accuracy for the Index of Production

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SUMMARY

In recent times the key measure of quality used for the Index of Production (IoP) has been the revisions performance of key aggregates. This is published as a set of revisions triangles alongside the monthly IoP release on the National Statistics website. Additionally, the IoP homepage on the website has a link to a Summary Quality Report which describes other aspects of quality of the series, for example, their timeliness, punctuality and relevance. This article sets out the results of recent further work on another dimension of the quality of these series: the accuracy of the estimates, based on an analysis of their sampling error. Additionally the article introduces an approach to defining quality bands for each series, to allow users to compare the relative quality of different IoP components.

The Index of Production (IoP) measures the volume of production of the manufacturing, mining and quarrying, and energy supply industries, which covered 18.6 per cent of the United Kingdom (UK) economy in 2003. The IoP is a monthly time series with annual and quarterly data also available.

The Index of Manufacturing (IoM) covers the 14 sub-sectors of manufacturing and these are aggregated to form the resulting monthly manufacturing output time series. The IoM is widely used as a short-term economic indicator in its own right, and the manufacturing industries made up 79.2 per cent of the total IoP in 2003.

The IoP has three primary uses:

- as a short-term economic indicator in its own right. The Government, HM Treasury and the Bank of England, among others, monitor the IoP as an important indicator of industrial activity. The IoP is usually published 26 working days after the end of the month – the earliest official indicator on the performance of UK industry
- as a component of the production or output measure of gross domestic product (GDP). GDP measures the sum of the value added created through the production of goods and services within the economy, and
- as a requirement for the Statistical Offices of the European Community (Eurostat). Information on production and current price sales are provided to Eurostat. These are used with data from other countries to construct EC indices, published on a monthly basis

Ideally, the IoP would measure changes in value added of the production industries each month. On a short-term basis it is difficult to measure all the outputs and inputs in an industry, so the IoP measures changes in gross output. This is deflated turnover plus the change in inventories for work in progress and finished goods.

The IoP is published as a First Release. The Release disaggregates the manufacturing sector into seven industrial sectors as well as showing the main industrial groupings and the oil and gas extraction industry. The Release focuses on the standard three-month on previous three-month percentage movements. The IoP is a monthly series and news agencies and media generally focus on the monthly percentage change in the level of the index. However, monthly movements can be volatile, and the Office for National Statistics (ONS) gives prominence to three-month on previous three-month movements.

A link to the methodology for the IoP can be found in the References section.

New measures of quality for the Index of Production

In recent times, ONS has published information of the revisions performance of the IoP as a measure of its quality. Revisions performance is useful, but is somewhat limited as a quality measure, since it tells us nothing about the accuracy

of the estimates themselves. In response to this shortcoming, ONS has now developed an additional measure of the quality of the published series. This is the standard error of the annual growth rate of each series. It provides a guide to how well series meet users' purposes, although different users have different requirements. Before looking at the standard errors themselves, it is helpful to be clear what they say about the quality of the series (see **Box 1**).

Method of estimation

The estimation of standard errors for official statistics has long been recognised as being very difficult. Standard errors exist for few composite measures due to the complexity of calculating estimates from multiple data sources. For the IoP, ONS has used a technique that simplifies the method of estimation. The calculation of the standard errors of the IoP required first the calculation of the variance of each individual component series. This section describes how this was carried out and how it was used as the basis for the calculation of the variance of each aggregate series, including the total IoP itself.

There are four main data sources used to compile the majority of the IoP:

- Monthly Production Inquiry (MPI)
- Quarterly Stocks Inquiry (QSI)
- Producer Price Indices (PPI), and
- Export Price Indices (EPI)

In essence, the IoP is constructed as a combination of sales growth from the MPI, deflated by the PPI and EPI, with changes in stocks from the QSI deflated by stocks deflators, which are also derived from PPIs. The main source of variance estimates for the IoP is turnover data from the MPI.

A new technique has been developed to estimate variances for the IoP. The approach used is to partition the total variance of the growth rate for a given industry domain into contributions from the following additive components:

- total sales
- inventory changes
- the differential movement of domestic and export sales
- export price indices
- producer price indices
- the effect of lagging deflators for inventory changes

Each of these components is a sum of variances, each multiplied by the appropriate squared weight. For sales and inventories, summation is across industries. For EPIs and PPIs, summation is across products. This approach simplifies the computations considerably because there is no need to consider explicitly the covariances between industry deflators that use the same price deflators. It has the added advantage of allowing the user to see easily the contributions made by the different data sources. A demonstration of this can be seen in the Appendix.

Exploratory work using the new method demonstrated that nearly 95 per cent of the total variance of the main industry IoP is attributable to the variance of the MPI data. For this work, therefore, ONS has computed estimates of variance for the IoP using only sales data from the MPI. Using this approximation meant that complicated problems matching data between the MPI and deflators were avoided, and so estimates of variances could be computed for much larger time periods. The longer series of variance estimates ensures more reliable quality measures. However, not all of the production industries are sourced to the MPI. The industries not covered are all volume series and their data are collected from different sources by various other government departments and trade associations. In these cases, the methodology used means that it would be very difficult to produce standard errors and therefore there is no standard error estimate calculated for the non-MPI industries.

Quality bands for the Index of Production

To provide users with a sense of the relative quality of each IoP series, ONS has established four quality bands into which each series has been allocated. After examination of the possibility of using composite quality measures based on a range of different indicators weighted together, it was felt that a simpler method using just the standard errors and growth rates of the series could be more easily motivated. The rationale for this approach is similar to that used for the average earnings index (Youll, 2002).

The four quality bands are denoted A, B, C and D and define the relative quality of the series, but say nothing about quality in absolute terms. Nor are labels attached to the bands (for example, A = excellent, B = good and so on). Such labels are likely to be unhelpful, since they will mean different things to different people. The quality bands simply indicate that those in band A are of higher quality (have greater accuracy) than those in band B, and so on.

The choice of where to drawn the lines between adjacent bands is guided by the need to provide a reasonably equal number of series in each band. This makes

Box 1

What is a standard error?

The difference between an estimate and its true value is known as the sampling error. The actual sampling error for any estimate is unknown, but a representative error can be estimated from the sample and this is known as the standard error. This provides a means of assessing the accuracy of the estimate of growth: the lower the standard error, the closer the estimate of production growth is likely to be to its true value. In fact, the degree of confidence can be expressed more precisely. If estimates of the true production growth rate were obtained from many different samples, then approximately two-thirds of these estimates would be less than one standard error away from the true value and approximately 95 per cent of them would be less than two standard errors away from the true value. Standard errors are often presented in terms of confidence intervals around an estimate.

For example, if the standard error for an estimated growth rate of 4.0 per cent is 0.4 percentage points, then the estimate of 4.0 per cent has a 95 per cent confidence interval of 3.2 per cent to 4.8 per cent (that is, 4.0 per cent ±2 standard errors). One further way to express the standard error is as a percentage of the estimate itself. This is referred to as the coefficient of variation (CV) of the estimate. In the example above, the estimated growth rate of 4.0 per cent has a CV of 10 per cent (that is, 0.4/4.0 expressed as a percentage).

maximum use of distinction between bands. If this approach were not used then, at an extreme, if bands B, C and D were chosen such that there were no series in these bands (that is, all series were defined as band A), the power of the banded approach would be lost. To achieve a reasonable allocation of series to each quality band, the following criteria were used:

- the average standard error of the annual growth rates
- the sample size
- the achieved sampling fraction (after taking into account non-response)
- the smoothness of the series (as a measure of the signal to noise ratio)

Results

Based on the criteria for defining each quality band described above, **Figure 1** shows where each of the detailed component series which make up the total IoP (there are 224 of them) fall on a scatter diagram, plotting the 2005 median growth rates against the median standard errors.

Aggregate series based on these detailed component series have also been allocated into quality bands, using the same criteria.

Table 1, **Table 3** and **Table 4** show the 2005 median growth rates, standard errors and quality bands for the total IoP, IoM, main industrial groupings and sub-sector series level. The 2005 median growth rate denotes the median of the annual growth rates for each month in 2005. The 2005 median standard error denotes the median of the standard errors of the annual growth rates for each month in 2005. **Table 2** shows the annual growth rates, standard errors and quality bands for each month in 2005 for the total IoP. The IoP weights in each figure do not sum to 1,000 due to the non-MPI-sourced industries having no standard error calculated.

Figure 1
Quality bands based on the median growth rate against the median standard error for each four-digit production industry, 2005

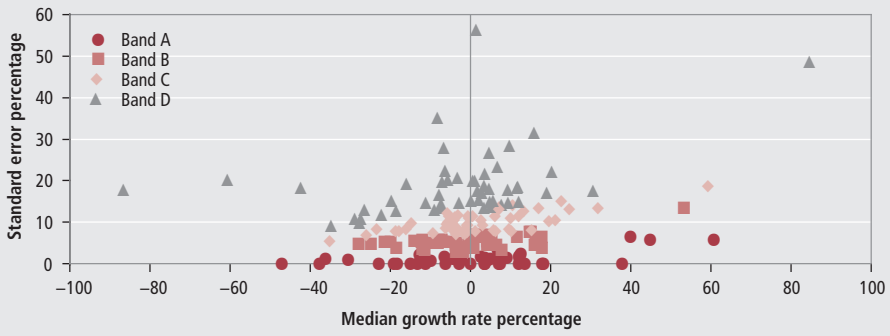

Table 1
Quality band measures for the IoP and IoM, 2005

Industry	Median growth rate (per cent)	Median standard error (per cent)	Quality band
Production	*0.1*	*0.8*	A
Manufacturing	*–0.1*	*1.0*	A

Source: Office for National Statistics

Table 2
Quality band measures for the IoP, January to December 2005

Production industries	Growth rate (per cent)	Standard error (per cent)	Quality band
January	*0.5*	*0.8*	A
February	*1.7*	*0.8*	A
March	*–1.5*	*0.7*	A
April	*0.3*	*0.8*	A
May	*4.2*	*0.8*	A
June	*1.0*	*0.8*	A
July	*–2.2*	*1.1*	A
August	*4.0*	*0.9*	A
September	*–0.1*	*0.8*	A
October	*–1.3*	*0.8*	A
November	*–0.9*	*0.8*	A
December	*–0.2*	*0.8*	A

Source: Office for National Statistics

Further developments

The figures in the previous section provide a snapshot of the quality of the IoP and its component series, based on the average standard errors in 2005. In that sense, the measure is static, and it is not intended to update this each time the index is published. The standard errors over the period considered in the forgoing analysis were reasonably stable for each series and so provide a robust indication of the current quality of the published IoP and component series. However, there are a number of developments to the IoP in the coming months which are likely to lead to significant changes in the quality and relative quality of the IoP and published components. In particular:

- a reduction in the sample sizes of the two main surveys used to produce the IoP, namely the Producer Prices Survey (used to produce PPIs) and the MPI. The PPI survey was reduced by 25 per cent at the start of 2007, and a 17 per cent reduction in the sample size for the MPI is planned for later in 2007
- a revised sample allocation for the MPI is also planned at the same time as the reduction in the sample size. The combined effect of sample cuts and revision should be to reduce the standard error of the IoP
- the variable used to calculate population estimates from sample values will be changed from employment to turnover when the MPI sample is reduced. Turnover for the population as a whole more closely correlates with the sampled estimate of turnover than does employment, and so this change will lead to a further reduction in the standard error of the IoP
- finally, in early 2008, it is planned to carry out a more thoroughgoing update of the MPI sample, including redrawing the stratification of the sample. Again, this will reduce the standard error of the series

Table 3
Quality band measures for the IoP main industrial groupings, 2005

Main industrial grouping	Median growth rate (per cent)	Median standard error (per cent)	Quality band	IoP weight (parts per thousand)
Consumer durables	*–2.4*	*3.2*	B	36.1
Capital goods	*–0.8*	*1.9*	A	189.5
Consumer non-durables	*–0.7*	*1.6*	A	249.4
Intermediate goods	2.7	1.9	A	253.2

Source: Office for National Statistics

Table 4
Quality band measures for the IoP sub-sector industry level, 2005

Sub-sector industry level	Median growth rate (per cent)	Median standard error (per cent)	Quality band	IoP weight (parts per thousand)
Mining and quarrying except energy-producing materials (CA)	*14.2*	*3.4*	A	8.3
Manufacture of food products, beverages and tobacco (DA)	*2.1*	*1.1*	A	88.0
Manufacture of textiles and textile products (DB)	*–7.2*	*5.5*	B	23.6
Manufacture of leather and leather products (DC)	*–11.3*	*8.0*	C	2.5
Manufacture of wood and wood products (DD)	*0.1*	*10.4*	C	14.7
Manufacture of pulp, paper and paper products; publishing and printing (DE)	*–3.3*	*3.4*	B	107.7
Manufacture of chemicals, chemical products and man-made fibres (DG)	*0.8*	*1.4*	A	87.4
Manufacture of rubber and plastic products (DH)	*3.2*	*5.8*	B	41.4
Manufacture of other non-metallic mineral products (DI)	*3.4*	*2.7*	A	29.8
Manufacture of basic metals and fabricated metal products (DJ)	*12.7*	*5.1*	B	75.9
Manufacture of machinery and equipment not elsewhere classified (DK)	*1.9*	*2.9*	A	66.0
Manufacture of electrical and optical equipment (DL)	*–10.8*	*3.3*	B	84.9
Manufacture of transport equipment (DM)	*1.1*	*2.2*	A	62.6
Manufacturing not elsewhere classified (DN)	*–2.8*	*6.5*	B	35.2

Source: Office for National Statistics

Taken together, it is not yet clear how these changes will affect the quality of individual IoP component series. However, research in ONS indicates that higher level aggregates (roughly division or two-digit Standard Industrial Classification components) will be improved by these changes, that is, their standard errors will be reduced.

An update of the results presented in this article will be published once the above changes have been implemented and 12 months of data are available to produce a stable average of the standard errors.

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REFERENCES

Bucknall R, Parkin N, Sova M and Wood J (2006) 'Estimation of Standard Errors for the UK Index of Production', *Survey Methodology Bulletin 59*, pp 1–10 and at www.statistics.gov.uk/events/gss2006/downloads/C1Parkin.doc

Full S and Lewis D (2001) 'Estimating sampling errors for movements in the UK index of production', *Proceedings of the Statistics Canada Symposium*, 2001 at www.statcan.ca/english/freepub/11-522-XIE/2001001/session15/s15d.pdf

Kokic P N (1998) 'Estimating the sampling variance of the UK Index of Production', *Journal of Official Statistics*, 14, pp 163–79 and at www.jos.nu/Articles/abstract.asp?article=142163

Rees M (2007) 'Summary Quality Report for the Index of Production' at www.statistics.gov.uk/statbase/product.asp?vlink=6230

Walton A (2005) 'Methodology for the Index of Production'. Non-journal article at www.statistics.gov.uk/articles/nojournal/IOPMethodology.pdf

Youll R (2002) 'Quality of the estimates of earnings growth from the Average Earnings Index', *Labour Market Trends* 110(4), pp 207–13 and at www.statistics.gov.uk/articles/labour_market_trends/AEI_estimates_apr2002.pdf

APPENDIX

Demonstration of decomposition of standard errors into data sources

The main contribution to the estimated variance of growth in the all-industry IoP from September 2003 to September 2004 comes from MPI data. **Table A1** demonstrates this, showing the estimated standard error (in percentage points), the corresponding variance (in percentage points squared) and the proportion of that variance attributable to each of the four main data sources:

- Monthly Production Inquiry (MPI)
- Quarterly Stocks Inquiry (QSI)
- Producer Price Indices (PPI)
- Export Price Indices (EPI)

Clearly, at the all-industry level, the dominant contribution is from MPI, which accounts for almost 95 per cent of the total IoP variance. This dominance remains, with a few exceptions, at all levels of aggregation. At main industrial groupings (MIG) level, MPI consistently dominates as the main source of variance, as illustrated in **Table A2** and **Figure A1**.

The main source of variance for IoP is turnover data from the MPI. Nearly 95 per cent of the total variance is attributable to the MPI. Figure A1 illustrates the dominance of the MPI. The contribution of each MIG to the total IoP variance is shown as a percentage (y-axis), subdivided according to the contribution of the different sources within each MIG (different colours).

Table A1
Estimated variance for the IoP, September 2003 to September 2004

				Percentage of all industries variance			
Weighted variance (percentage of total)	Weight	Standard error (percentage points)	Variance (percentage points squared)	Monthly Production Inquiry	Quarterly Stocks Inquiry	Producer Price Indices	Export Price Indices
100.0	100.0	0.79	0.63	*93.8*	*3.3*	*1.4*	*1.4*

Source: Office for National Statistics

Table A2
Estimated variance for the Index of Production at MIG level, September 2003 to September 2004

					Percentage of all industries variance			
Main industrial groupings	Weighted variance (percentage of total)	Weight	Standard error (percentage points)	Variance (percentage points squared)	Monthly Production Inquiry	Quarterly Stocks Inquiry	Producer Price Indices	Export Price Indices
Capital goods	26.62	22.05	1.82	3.32	*91.8*	*2.0*	*1.5*	*4.7*
Consumer durables	3.17	3.66	3.79	14.34	*92.5*	*5.2*	*1.3*	*1.0*
Consumer non-durables	47.23	25.81	2.07	4.30	*95.9*	*2.8*	*1.1*	*0.2*
Energy	0.00	21.74	0.00	0.00	*0.0*	*0.0*	*0.0*	*0.0*
Intermediate goods	22.98	26.73	1.40	1.95	*91.5*	*5.9*	*2.2*	*0.4*

Source: Office for National Statistics

Figure A1
Weighted variance of IoP growth at MIG level as a percentage of total weighted variance, September 2003 to September 2004