FEATURE

Graeme Chamberlin
Office for National Statistics

Monitoring the coherence of ONS and Purchasing Managers' Index data

SUMMARY

This article outlines a methodology for monitoring the coherence between official data published by the Office for National Statistics and business survey data in the form of Purchasing Managers' Indices (PMI). PMI data, particularly relating to the services sector, are being increasingly used by policy-makers and analysts in forming their view of current economic trends. The article demonstrates that what may sometimes appear as significant divergence between the two sources can often be accounted for by differences between their coverage and that the underlying signals in the two approaches are generally coherent.

Although the Office for National Statistics (ONS) is the official supplier of data on the UK economy, a number of other organisations and trade associations conduct surveys of economic activity. These tend to be more qualitative and based on smaller samples but are still regarded by many as useful and timely indicators. The most prominent and widely used is Purchasing Managers' Index (PMI) data. These are surveys of the UK private sector manufacturing, construction and services industries administered by NTC Economics on behalf of the Chartered Institute of Purchasing and Supply (CIPS). See www.ntceconomics.com for further details relating to the coverage and methodology of PMI data.

Recently, policy-makers and analysts are placing some emphasis on PMI data in forming their short-term view of the economy. Although later vintages of ONS data are recognised as the best data set, preliminary or early estimates of the economy are treated more cautiously. This is primarily due to the uncertainty created by expected revisions as ONS incorporates new information from annual data sources and makes methodological improvements in the way it measures the economy.

The Bank of England (BoE) has gone the furthest down this road. Ashley *et al* (2005) describes how early ONS estimates might be combined with PMI survey balances to form better short-run forecasts of the UK economy. This is part of an ongoing programme of work into dealing with what BoE have coined as 'Data Uncertainty' (see Cunningham and Jeffery 2007). Although BoE is at the forefront of the international research agenda, the analysis of real time data for the purposes of policy-making has gathered strong momentum in recent years. It is therefore possible that variants of the techniques being developed by BoE will be applied elsewhere.

Monitoring coherence between ONS and PMI data is therefore a useful exercise, regardless of the finding. If the two sources paint the same picture, then data users may have enhanced confidence in their reading of the statistics. A reporting of divergent trends, though, could have the opposite effect. In such cases, the official data may be scrutinised more heavily and there might be greater expectations of future revisions. A recent article by Meader and Tily (2008), published in *Economic & Labour Market Review*, describes how ONS continuously monitors the quality of its data, including in the appendix how coherence against external data is assessed. The purpose of this article is to outline in more detail how this is done.

However, it must be accepted that, even if ONS and PMI data are telling a coherent story, it does not rule out future revisions to official statistics. In fact, the correlation between PMI and preliminary estimates is usually greater than the correlation between PMI and later data vintages. Neither is it the case that incoherence necessarily implies future revisions. Often, revisions can work in the opposite direction, leading to greater divergence between the two data sources.

The next section outlines a basic

methodology and discusses some of the issues involved in statistically testing for coherence. The underlying premise is that, although both do it imperfectly, each survey is designed to capture the same underlying economic activity. Therefore, coherence tests are based on a comparison of the signals in the data. Once the methodology has been outlined, it will be used in assessments of UK private sector manufacturing, services and total output.

Measuring coherence

This section outlines a five-step approach to monitoring coherence between ONS and PMI and discusses some of the issues involved.

Adjustments to 'like for like' basis

Although the industry coverage of the manufacturing and construction industries is broadly similar, the same cannot be said for the services sector. It will be shown that the coverage of the PMI Report on Services is more limited than the ONS Index of Services (IoS). This is a critical issue when assessing the coherence of the data. Divergent trends may simply reflect movements in industries that ONS captures in its data, but the PMI does not. For the purpose of monitoring coherence, ONS data should be adjusted so that their coverage is the same as PMI.

Investigate correlation

There are a number of reasons to believe that the correlation coefficient of ONS data is greater with lags of the PMI. First, ONS data are usually reported as a three-month on three-month growth rate whereas the PMI reports a monthly balance. Therefore, the ONS data are based on a six-month period, whereas the PMI covers just one month. Second, early vintages of ONS data have a relatively low data content (see Skipper 2005), with missing data replaced by forecasts based on extrapolating past trends. Finally, responses to the PMI survey may be influenced by confidence factors and responses to prospective questions in the survey, and hence incorporates a forward-looking element.

Standardise the data

The main problem in comparing ONS and PMI data is that they measure the economy in different units. Headline ONS data provide a point estimate of output growth on a three-month on three-month basis. PMI survey data, though, ask respondents to simply state whether output or activity has gone 'up', remained 'unchanged' or gone 'down' during the latest month. The survey is published as the weighted balance between the percentages of 'up' and 'down' responses and normalised so that a statistic of 50 corresponds to aggregate 'no change'.

Comparing the data requires each to be expressed in a common metric. Therefore, one of two possible actions is required. Either one data series is transformed in terms of the other, or both are mapped into standardised units. The normal practice has been to map survey data onto official data using either the regression approach (Pesaran 1984) or the similar probability approach (Carlson and Parkin 1975). There is now a substantive and increasingly sophisticated literature on these methods (see Nardo 2003 for an assessment).

Transforming both series into standardised units is a simple process. For a time series Y_t, standardised data can be found by subtracting the mean and dividing by the standard deviation.

$$Y_t^s = (Y_t - mean(Y)) / sd(Y)$$

The resulting data series Y_t^s has a mean of zero and a standard deviation and variance of unity. For comparison purposes, this will remove any long-term bias and map changes in the data onto the same scale.

Although far less technical than the regression-based approaches, there is an intuitively appealing characteristic of the result as both series are now viewed in terms of their own history. As the purpose of this article is simply to monitor coherence rather than form estimates of economic activity, the ease of this approach is appealing.

Signal extraction

As both data sources are published at a high frequency, they tend to be volatile, which makes it hard to judge when they have diverged in a significant and sustained way. PMI reports on manufacturing, construction and services are published monthly, as is the ONS Index of Production and IoS. When looking at the raw monthly data, there will be lots of instances where there are large unique differences but this often reflects the inherent volatility in higher frequency data and is not sustained. A comparison of high-frequency data is also likely to be affected by the treatment of seasonal variation and trading-day effects. There is little information on how, and the extent to which, these are corrected in PMI data.

These factors suggest that a clearer view of the data can be achieved by either using lower-frequency data or by smoothing. Once the data have been standardised, the signal in the data can be extracted using a simple state-space model estimated by the Kalman filter. This enables the user to ascertain whether the signals in the two data series are in fact different. For the purposes of measuring coherence, this is more illuminating; the question being asked is simply whether the two data sources share an underlying trend.

A standard signal extraction problem can be explored using the Kalman filter. This consists of two parts.

The measurement equation states that the standardised data from above consist of a signal (S_t) and an error component ($e_{1,t}$), where the signal is the component of interest, but is unobserved.

$$Y_t^s = S_t + e_{1,t} \qquad e_{1,t} \sim (0,1)$$

The state equation defines a law of motion for the unobserved signal. Given that the data are stationary (I(0)), it is assumed that a local trend model is appropriate, although almost any form of linear model could be used.

$$S_t = S_{t-1} + e_{2,t} \qquad e_{2,t} \sim (0,\mathrm{var}(e_2))$$

Here, the estimate of the unobserved signal in the data can be interpreted as a trend or smoothed version of the actual data. The degree of smoothing is implied by the variance var(e_2), which dictates the signal-to-noise ratio, that is, the relative variance of the signal and error component, and can be estimated freely using maximum likelihood. As the signal-to-noise ratio increases, more of the variance in the measured data is regarded as a signal, so S_t tracks the measured data Y_t^s more closely. As the signal-to-noise ratio falls, more of the variance in the measured series is allocated to the noise component $e_{1,t}$, hence the resulting signal estimates become smoother.

Testing divergence

Once signals have been extracted from the ONS and PMI data, they can be plotted for comparison purposes. Because the data have been standardised and much of the volatility removed, this plot can be used to informally judge coherence. A standard t-test with T-1 degrees of freedom can then be used to formally assess when the divergence, measured as $D_t = S_t^{ONS} - S_t^{PMI}$, is greater than zero at the 5 per cent significance level. This corresponds to where the differenced series (D_t) moves

outside a 95 per cent confidence interval centred around zero.

However, care must be taken in interpreting the outcome of this test. The width of the confidence intervals depends largely on the variance of the past deviations. Hence, if it is fairly common for two series to diverge in a large way, the confidence interval will be wide, so only the largest of the deviations will be judged as statistically significant. Likewise, if two series are closely aligned, then small deviations may be judged as significantly different from zero. This implies that measuring coherence is a relative proposition based on the past history of the data and that a strong role for judgement remains.

Further issues

Divergence often results from unsynchronised movements in the data. For example, both series may report an acceleration in activity or output, but if one series reacts slightly before the other, then a deviation will arise even though the data are generally reporting the same story. The same would be true concerning turning points; a short lag in one survey can lead to fairly large divergence in the data.

Although both data sets can be transformed into common units, there is no reason to expect exact coherence due to the different methodologies applied in each case. Therefore, some incoherence should not be surprising and necessarily alarming for official statisticians. There are a number of reasons that might account for differences between the two data sources, which reflects how the statistics are produced rather than their interpretation of economic activity.

Firms can respond to the ONS survey in a continuous way, meaning that any point estimate of output can be recorded. The response to the PMI survey, though, is discrete; only one of three possible answers can be given. As a result, the PMI survey is limited because respondents have little ability to report an order of magnitude to output movements.

For example, suppose the majority of firms in the survey reported a small decline in output over the period. This could generate a large number of 'down' responses and an overall plunge in the reported balance. As a result, the survey could report a strong contraction even though in actuality there is just a strong consensus that the contraction is relatively minor. Suppose, though, that there was an equally strong consensus that the fall in output had been severe. As firms can only respond with a 'down' answer, the reported balance statistic would be similar. The same balance statistic can then arise for very different output movements.

There is also little reported information on how firms generally respond to qualitative surveys. Are firms influenced by subjective expectations about the future or confidence when compiling their answers? Is there possible endogeneity between PMI and ONS data, in that well-publicised and reported official data might determine the responses firms give to business surveys? Finally, is there inertia in firm responses with a tendency to report what was reported last time?

Figure 1
Index of Manufacturing and the PMI Report on Manufacturing

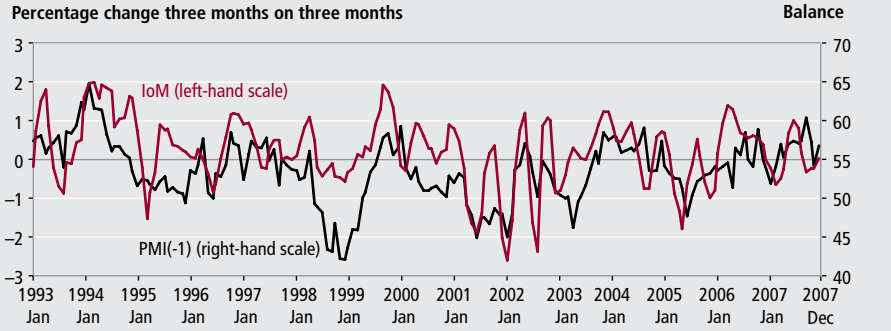


Figure 2
Signal extracted data for UK manufacturing output

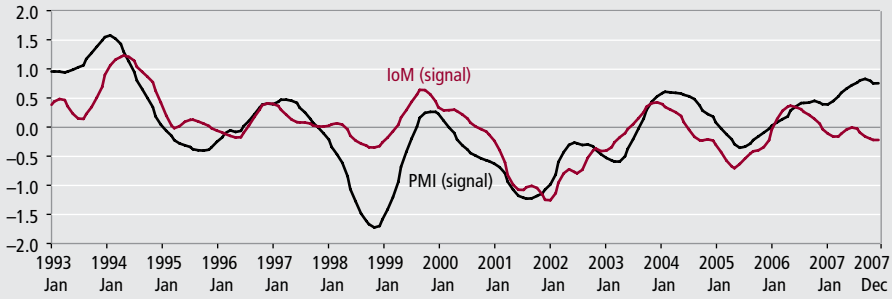
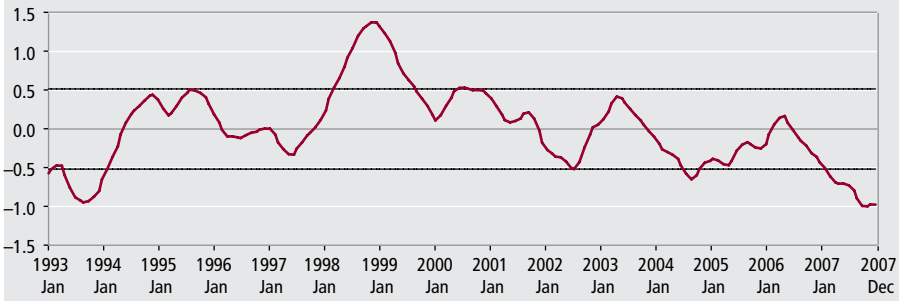


Figure 3
t-test for divergence between latest ONS and PMI signal extracted data on manufacturing



Coherence of ONS and PMI data

In this section, the methodology outlined above is used to monitor coherence of ONS and PMI private sector output data for the manufacturing and services sectors and for the whole economy.

Manufacturing

A one-month lag of the PMI data shares the highest correlation with ONS Index of Manufacturing (IoM). A comparison of the raw data is shown in **Figure 1**. **Figure 2** plots the signals extracted from both time series after the data have been standardised, and **Figure 3** shows the results of the t-test for divergence.

Three significant periods of incoherence are evident from Figure 3. These are in 1993, 1998–99 and 2007, where the official data are, respectively, weaker, stronger

and weaker than the corresponding PMI measure. The first of these appears to reflect a synchronisation issue in how quickly the sector recovered from the recession in the early 1990s, with the official data lagging the PMI. The second period is more of a curiosity, and reflects a genuine disagreement on the strength of the economy at the time. PMI balances in late 1998 were close to where they were in 1991, but the official data would imply that the later slowdown was modest in comparison with the previous one. Nor is it likely that this incoherence will be corrected by revisions to the National Accounts, which have actually worked in the opposite direction, widening the gap between the two time series. Throughout 2007, ONS data on manufacturing output appear to have been weaker than their PMI counterpart. It is not yet known whether or how future revisions will alter this perception.

Services

It is the service sector where most interest on the coherence of ONS and PMI data has focused. Not only is it the largest component of private sector output and GDP, it has also been subject to greater revision than the IoM, so early or preliminary estimates have been treated cautiously. Ashley *et al* (2005) reports that BoE attaches a fairly low weight to early ONS estimates of the IoS relative to the corresponding PMI data. Without any 'real-time' and 'out-of-sample' testing, it is difficult to validate BoE's findings, but these results were of concern to ONS.

Despite criticisms, ONS is actually at the forefront among National Statistics Institutions throughout the world in measuring what is typically a difficult part of the economy to measure. Tily (2006) outlines in some detail these challenges, recent improvements made by ONS to the monthly IoS, and discusses the programme of methodological improvements to deliver further improvements in the future. At present, the UK is the only country in the world to have developed a monthly indicator for the whole of the service sector based on internationally accepted methodologies.

Following Butler (2005), it is recognised that the coverage of the PMI data for the UK service sector is a subset of the official data, and this is a critical factor is assessing coherence. Most significantly, the public and distribution sectors are excluded which, according to 2003 weights, account for approximately 40 per cent of the IoS. Another important difference is the treatment of the financial services industry.

Presently, an adjustment is made to official statistics which takes into account that much of the output of the financial sector is just the intermediate consumption of other parts of the economy. For example, banking, insurance and financing costs incurred by businesses are simply treated as inputs into production, so the rationale for excluding them is to avoid double counting in much the same way as the output of the steel industry would not be added to the shipbuilding industry. This financial services adjustment (FSA) is made by allocating part of the output of the industry to a separate category which is subtracted from the overall IoS.

Table 1 shows how the coverage of the IoS relates to the PMI data on services. For the purpose of judging coherence, an adjusted IoS is formed and is plotted with the third lag of the PMI data in **Figure 4**.

Using the methodology described in the previous section, the signal view can be extracted from each series and is plotted for comparison in **Figure 5**. From first glance, the data look to be fairly consistent over the last two years. However, official data were relatively strong in 1998–99, but weaker in 2004. This is confirmed in **Figure 6** which plots the results from a t-test on the divergence of the signals.

Figure 7 presents the signal extracted views of different measures of the IoS and shows the importance of the like-for-like adjustment. For example, in 2001–02, the relative strength of the distribution and government sectors meant that the unadjusted IoS was relatively more buoyant than the adjusted series. However, since 2006, the adjusted IoS has been above

Table 1
Coverage of IoS and services PMI data

Component	IoS weight (2003)	Included in PMI data (Y/N)
Motor trades	28	N
Wholesale	59	N
Retail	77	N
Hotels and restaurants	42	Y
Land transport	29	Y
Air transport	8	Y
Supporting and auxiliary transport services	24	Y
Post and telecommunications	40	Y
Financial intermediation	70	Y
Financial services adjustment	-62	N
Real estate	34	Y
Computer and related activities	39	Y
Other business activities	129	Y
Public administration, defence and compulsory social security	70	N
Letting of dwellings	106	Y
Education	79	N
Health and social work	96	N
Sewage and refuse disposal	9	N
Activities of membership organisations	8	Y
Recreation, cultural and sporting activities	39	Y
Other service activities	8	Y
Private households with employed persons	7	N
Total weight	**1,000**	**576**

Figure 4
Adjusted Index of Services and the PMI Report on Services

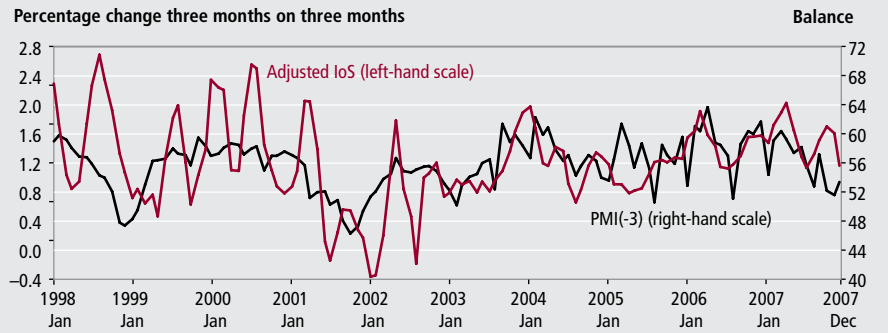


Figure 5
Signal extracted data for UK service sector output

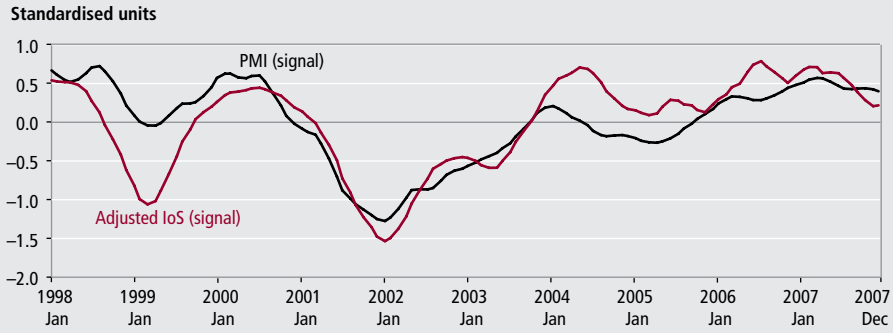


Figure 6
t-test for divergence between latest ONS and PMI signal extracted data on services

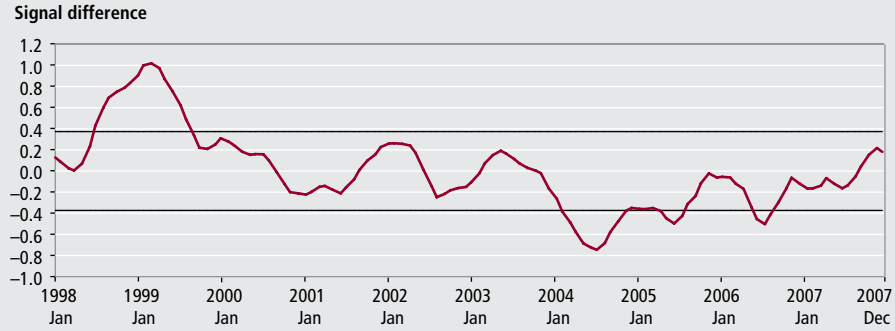


Figure 7
Alternative signal views of the Index of Services

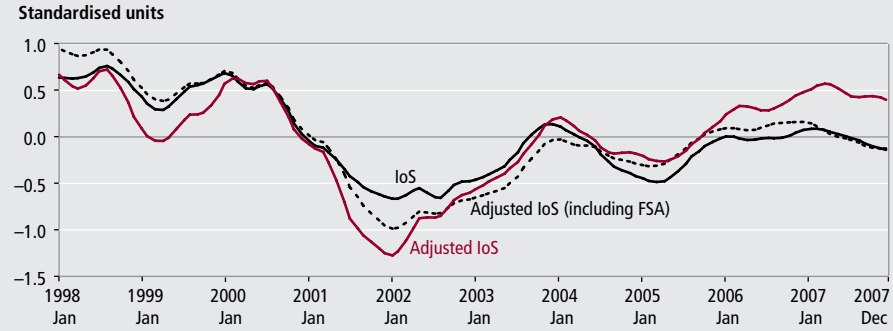
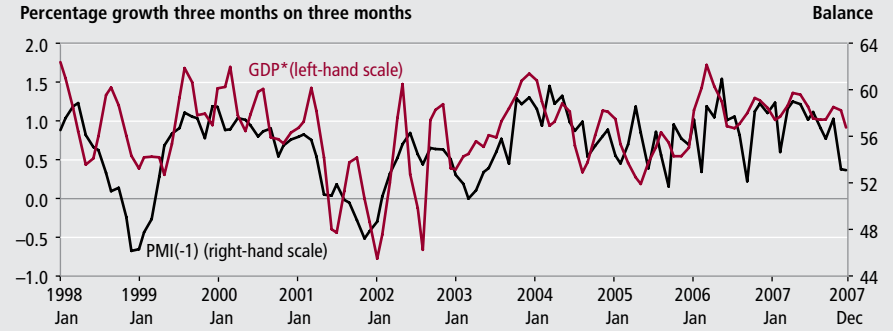


Figure 8
GDP* and aggregate PMI data



its recent average, whereas the IoS and the adjusted IoS including the FSA have been closer to their averages. This reflects the impact of the relatively fast-growing financial services industry on the index during this period, which is implicitly given a higher weight in the PMI.

Private sector output (GDP*)

Butler (2005) describes GDP* as the measure of GDP consistent with the industries covered in the PMIs for manufacturing, construction and services. The missing components are agriculture, mining and extraction, water and energy supply, and the distribution, public sector and financial services adjustment parts of services sector. Altogether, these account for approximately 40 per cent of the UK economy.

Testing coherence requires construction of a measure of GDP* and a combined PMI of economic activity. GDP* can be calculated on a monthly basis by using the monthly IoM, the adjusted monthly IoS from Figure 4 and by interpolating and extrapolating quarterly data on construction output. This, and a one-period lag of the PMI data are plotted in **Figure 8**. In both cases, the sector data have been combined using the latest official weights.

After using the stated methodology, **Figure 9** and **Figure 10** would imply that ONS and PMI data are, for the most part, relatively coherent. The two periods of significant divergence are in 1998–99, when PMI data are much weaker, and in 2004-05, when PMI data were stronger than official data.

It has already been stated that PMI balances for manufacturing were similar in 1998 to the levels recorded in 1991. Although the PMI for services has only been published since 1996, backcasting using another business survey on the service sector, published by the British Chambers of Commerce, also suggests that it might have been close to 1991 levels had the survey existed at this time. The evidence suggests that because respondents cannot attach an order of magnitude to their stated output movements, it is possible that the strong negative balances in 1998 just reflect a strong consensus of a relatively mild downturn.

Preliminary estimates of service sector output also pointed to weaker growth, but have since been revised significantly upwards. Here, revisions have actually generated rather than corrected the incoherence between the surveys.

Economic news was certainly pessimistic in this period. The Asian financial crisis, the near collapse of Long-Term Capital Management, and weak global growth indicated that the UK economy might be constrained by a global recession, all of which dented business confidence.

However, it has since emerged that consumer spending in the UK was more resilient than early estimates suggested, growing at rates above its long-term average since 1975 throughout 1996–99. Between October 1998 and June 1999, monetary policy was loosened considerably, with interest rates falling from 7.25 per cent to 5 per cent, including three 0.5 percentage point monthly reductions.

Whether the finding of incoherence in the 2004–05 period will be altered by future revisions is not so clear cut. During the 2006 *Blue Book*, economic growth for the second half of 2004 and first half of 2005 was actually revised downwards. However, due to the reduced scope of the 2007 *Blue Book* as ONS undertakes the re-engineering of the National Accounts, these data are yet to pass through their second *Blue Book*. Hence it is possible, but not guaranteed, that the extent to which the economy softened will be revised.

Conclusions

This article has attempted to measure coherence between ONS and PMI data. If it is accepted that both data sources attempt to measure similar economic activity, albeit imperfectly and with measurement errors, then both should be driven by similar underlying trends. Therefore, extracting and comparing the signals in the data forms the methodology for monitoring or assessing data coherence. The key issue appears to be adjusting ONS data so that their coverage reflects that of the PMI data with which they are compared. Once this is done, coherence between the two measures of economic activity is found to improve.

CONTACT

elmr@ons.gsi.gov.uk

Figure 9
Signal extracted data for PMI and GDP*

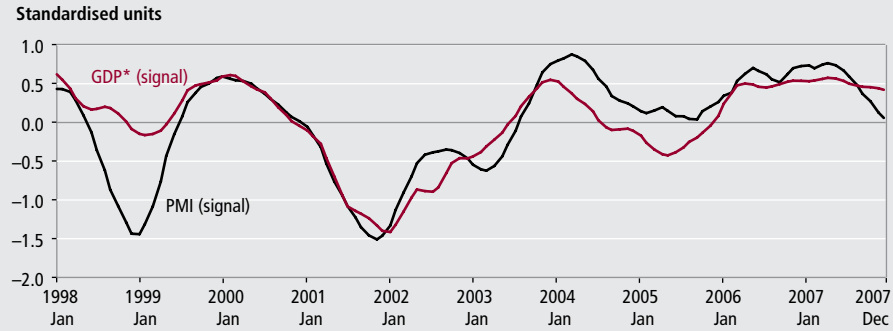
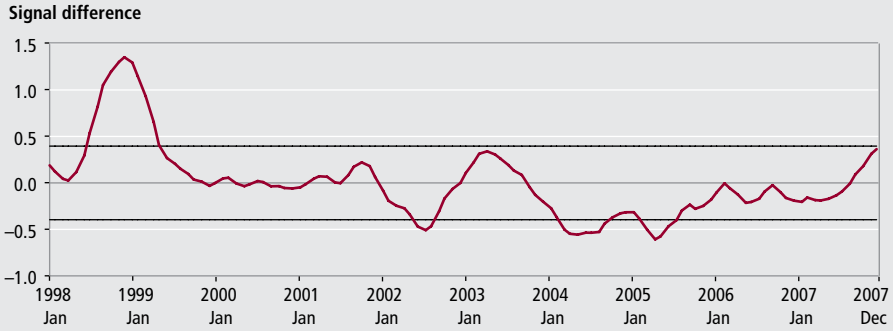


Figure 10
t-test for divergence between ONS and PMI signal extracted data on private sector output



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