

FEATURE

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Inventories: a cross-country comparison of behaviour and methodology

SUMMARY

There are a number of contrasting economic theories regarding companies' motivations for holding inventories. One theory suggests firms use inventories to smooth production levels over time in response to demand; another suggests firms have an optimal range of inventory levels which they will maintain by varying production levels. The purpose of this article is not to resolve this debate but instead to highlight the relationships within component inventories data, the relationships between gross domestic product and inventories and the relative importance of individual sectors' holdings within the series as a whole. Subsequently, a comparison of official data and external survey data within the UK will be discussed. In addition, the article aims to highlight the difficulty in measuring inventory data and discusses issues surrounding methodology.

This article will initially set out the theoretical basis behind inventory measurement, first defining change in inventories and then highlighting the intricacies and difficulties involved in the estimation process. The methodology followed in the UK will then be covered in some detail. A comparison of change in inventories in relation to gross domestic product (GDP) will be carried out for the UK and the US and some explanations put forward for these trends. Further to this, the manufacturing sector will be studied in some greater detail in order to expand upon the relationships behind the headline data. Finally, this article will compare Office for National Statistics (ONS) data to that of the Confederation of British Industry (CBI) as an external source of inventory figures.

Inventories are a crucial input of managing a firm's efficient production process. They are defined as 'the unsold stock of materials, stores and fuel, work in progress, finished goods and goods for resale held over a reference period' (European System of Accounts (ESA) 1995). In the UK, inventories data are published by ONS within the GDP release as a chain volume change in inventories series (chain-linking is a process used to fix the current year's quantities to the previous year's prices, in effect taking inflation into account). The inventories data are also available on a current price basis within the same release.

The difficulty in measuring inventories is due to price changes during the holding period, the effect of which need to be

removed. For example, an increase in the value of inventories which is brought about entirely by price changes does not represent a real change in inventories because the volume has remained the same. These holding gains may come in the form of a gain or a loss and can be calculated as the difference between the value of inventories at the end and beginning of the period, minus the actual change in inventories. The need to remove holding gains represents the root of most of the difficulties associated with compiling inventories data.

Ideally, information would be collected on the exact times and quantities of additions to, and withdrawals from, inventories and the price of the product at those times. If the ideal case were possible, much more analysis could be undertaken into the firm's reaction to the external environment. With this, the potential to accurately forecast the change in inventories series could be useful as an economic indicator. However, in reality, information is only available on opening and closing inventory book values as reported by the firm. In this case, change in inventories must be measured using an average price for the period. If the price has been constant, this is an exact measure – as is the case if there has been no change in quantity. However, when both price and quantity have fluctuated, change in inventories is only an approximation. The greater the fluctuation, the greater the need to calculate change in inventories over a shorter time period (monthly/quarterly) in order to capture accurate estimates.

UK inventory methodology

In the UK, ONS publishes change in inventories data on a quarterly basis within the GDP release. Data are available at an aggregate level and spilt down into certain industry sectors. In the UK, the alignment adjustment for the quarterly expenditure measure of GDP is applied to the inventories series; the adjustment does not affect the annual estimates (see **Box 1**). It is not known whether similar adjustments are applied to the quarterly inventories estimates in other countries. Therefore, all cross-country comparisons in this article use annual estimates.

The vast majority of data used to estimate the quarterly change in inventories series are collected in ONS survey questionnaires (specifically the Quarterly Stocks Inquiry). Each survey is tailored to the characteristics of the sector being covered and survey documents are accompanied by a set of explanatory notes to ensure firms understand the scope of the survey. This ensures that any changes in bookkeeping practices by the respondents

are captured, in order that consistency can be achieved between individual respondents and between different survey periods. Weights are applied at Standard Industrial Classification (SIC) level in order to estimate economy-wide book values from the survey responses. The difficulty in maintaining current weights consistent with the time period for respondents' information adds to the complexity of creating accurate series.

If a firm has previously contributed to the survey but is late returning data for the current quarter, an imputed value is calculated based on the average movement in inventories between quarters in the current and previous years.

If a firm is late in responding to the survey and is a new contributor (the ONS has a duty to spread the burden of survey responses and, as such, certain firms will rotate in and out of the survey sample), then a process of system construction is carried out whereby a construction ratio is created (see **Box 2**). The ratio gives a representative inventories value per head of

survey respondents; the new contributor's employment figure can then be used to estimate an inventory value for the quarter. Once this process is complete, the inventory book value data are ready to be processed into a chained volume data set.

The process of deflation must be applied to the book value inventories data in order to strip the holding gains from the series. It is essential that the appropriate index is used to specifically deflate the inventory series in question. ONS uses a large number of producer price indices; wholesale, construction and agricultural (supplied by the Department for Environment, Food and Rural Affairs) deflators; the all items retail prices index (RPI); and metal bulletin data to provide around 800 indices and derive around another 20 for use in the deflation process. The system also takes into account the fact that different types of inventory will not typically follow the same holding pattern; as such, it allows for varying holding periods for different types of inventory. Once this process has been carried out, the change in inventories series is ready for the top-level release.

The international comparisons in this article compare in detail the UK with the US and include a brief comparison with Australia and Canada. In terms of methodology, the UK follows the recommendations in the Eurostat Handbook on price and volume measures in National Accounts closely, using the best practice methods available (always falling into the category of an A method or a B method, where the former represents the ideal case and the latter the next best scenario). The level of detail provided by foreign statistics offices is generally on a par with, or more detailed than, that in the UK. Australia and Canada both report quarterly and annual data and the US also produces monthly inventories estimates. The US provides a wider breakdown of inventories than any of the other countries (nearly 80 individual series). The core components – manufacturing, wholesale and retail – are consistently reported by all statistical offices in the countries analysed.

Having outlined the methodology and potential difficulties in the inventories process, the focus of the article will now shift towards the actual figures and the relationships found in the data. The main focus will be the relationship between change in inventories and GDP but the relationships within the inventories series and some comparison to external survey data will also be discussed.

Box 1

The alignment adjustment

The final balancing step in calculating GDP is the incorporation of the calculated alignment adjustment which will sum to zero over a calendar year. These adjustments smooth the quarterly paths of income and expenditure estimates of GDP so that they match, as closely as possible, the movement in output without altering annual totals. In the expenditure analysis, the adjustments are allocated to changes in inventories and, within the income analysis, to the operating surplus of private non-financial corporations, as these areas are considered to have the widest error margins.

Box 2

The construction ratio

When a contributor is rotated into the inventories sample, and has not yet returned data, a constructed value is calculated. There is no back data on which to base an imputation, so the construction uses the employment level of the firm. It works out a stock value per head, and then multiplies this by the late contributor's employment.

- Non-response firms are removed from the sample cell and the remaining firms' employment numbers are added to the data
- If there are more than ten firms with response data, then outliers are removed:
 - a ratio is created for the returned value of change in inventory divided by the employment level, then
 - the top 10 per cent of firms are removed from this group and then from the remaining firms the bottom 10 per cent are removed
- For those firms that remain, the values for the change in inventories and level of employment are summed and the first is divided by the second to obtain the construction ratio for the series

Note that the choice of a 10 per cent trim is designed to minimise the degree of bias in creating the ratio; if the degree of skew in the data were significant, this might lead to an asymmetric trimming parameter.

GDP and inventories

Explaining the relationships

Figure 1 shows the relationship between movements in GDP and changes in inventories from 1948 or 1949 to 2006 (annual figures) in the UK. The period is dominated by a strong relationship between the two series from 1958 to 1997. However, looking closely at the movements before and after this period for the available data, the appearance is of an apparently weaker relationship. This deterioration in the relationship is confirmed when a correlation coefficient for the individual periods is calculated.

In the early post-war period, there appears to be no relationship between GDP and inventory movements. This period can be thought of as a 'recovery' phase after the Second World War and as such is excluded

from the analysis. Considering the period 1959 onwards, it can be seen that, until the 1990s, inventories track GDP movements closely. In the late 1990s onwards, the relationship becomes less clear.

The just-in-time (see Box 3) inventory system popularised in the 1950s sparked a period where change in inventories track change in GDP closely. If GDP is assumed to be an indicator of the demand for goods, then this relationship ties in with the notion that firms attempt to change their holdings in response to demand in order to minimise the level of stock at the end of any given period. It is also likely that, as the sophistication of computerised inventory management systems increased and the cost of introducing these systems decreased, firms became better able to effectively manage their level of inventories. If this is

the case, then it must be considered why this relationship appears to deteriorate from the mid 1990s, a period when relatively few economic shocks directly affected the UK economy.

A possible explanation for this deteriorating relationship could be the potential divergence between short-term GDP movements and the path of consumption in the UK economy. As consumers become more willing to fund current consumption through borrowing (as indicated by the spiralling UK debt to income ratio), movements in GDP may not be a good indicator of short-run future demand for goods from the private sector. If this is the case, then firms' ability to anticipate inventory requirements is lessened, which could help to explain the weakening relationship between GDP and inventories. Another potential factor influencing inventory behaviour would be the rapid rate of technological change (especially in computing and home entertainment goods), meaning certain inventory types will have a much shorter lifespan before becoming obsolete than has previously been the case. This could be an area where the inventories system may struggle to keep up.

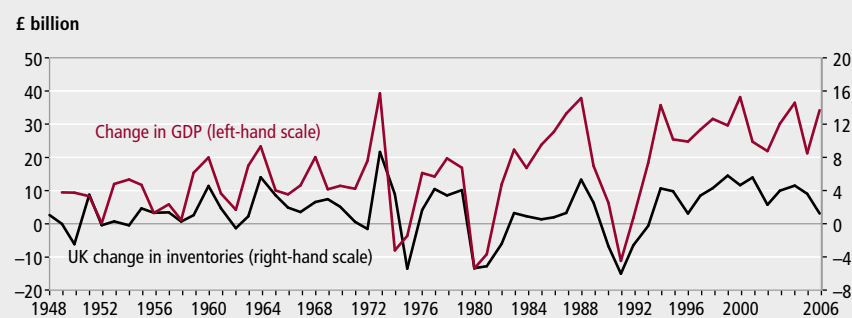
A second explanation of the deteriorating relationship comes from the costs associated in holding inventories. Inventories represent a form of investment by the firm. If firms are holding more inventories than in the past, it should be the case that the relative rate of return on inventory investment exceeds that of the other available options. One of the key determinants of return on alternate forms of investment is the rate of interest and, as such, there might be expected to be an inverse relationship between the real rate of interest and the change in inventories. As Table 1 shows, the real level of interest using both short- and long-term measures (calculated using RPI) fell by around 40 per cent during the second half of the 1990s, decreasing the return on alternative forms of investment.

Other factors which could affect the cost of holding inventories and therefore their relative appeal as an investment include:

- the cost of shortage – what is lost if the stock is insufficient to meet all demand (a stockout)
- the cost of space
- spoilage or inventory damage
- insurance

Deregulation and increased competition within insurance markets coupled with

Figure 1
GDP and inventories for the UK



Source: Office for National Statistics

Box 3

Just-in-time policy

The 'just-in-time' inventory system was first introduced by the Ford Motor Company in the 1920s and was popularised by the Toyota Motor Corporation in Japan in the 1950s. Utilising the forward steps in transportation technology in the post-war period, this process considers the holding of inventories to be a wasteful endeavour, imposing needless storage costs and opportunity cost to the firm. The system therefore aims to minimise the reliance on stocks as a buffer in order to reduce costs as much as possible. The advances in computer technology throughout the mid/late 20th century also improved the ability to implement a just-in-time production technique.

There is a risk involved with a just-in-time strategy as it leaves the firm with no protection to demand and supply shocks. If demand increases at such a rate that production capacity is insufficient to meet output requirements, the firm will lose out on custom. If there is a negative supply shock which affects the short run availability of key inputs, then the firm will have little or no outstanding inventory stock to meet existing contracts as well as losing out on new business.

Table 1
Real lending rates (short- and long-term)

	Long-term rates (20-year government bonds)	Short-term (Bank of England base rate)
1980–1989	3.73	4.33
1990–1995	4.62	4.60
1996–2005	2.78	2.73

technological developments, including the internet, has led to a broad decrease in the premium of insurance policies within the UK. As a result, the spoilage cost of inventory holdings will also be reduced. However, it seems likely that the cost of space in which to store inventories increased over the same period. Therefore it is unclear as to the direction of real cost movements with regard to holding inventories.

The inventories data time series for the US starts in 1968 so does not allow analysis of the early post-war period. Using the data available, change in inventories and change in GDP exhibit a strong correlation which does not suffer the same degree of deterioration during the late 1990s seen in the UK (see **Figure 2**). The chart presents data in US dollars rather than sterling so the actual numbers should not be compared

with **Figure 1**. It is the relationship in the movement of the series that is being considered at this point; the relative importance of inventory movements in terms of total GDP is considered below.

The data for Canada show a similar relationship between GDP and inventories to the UK; there appears to be a reasonably strong relationship between the series until more recent years, when the relationship weakens. The data for Australia suggest a much weaker relationship throughout the period.

The cyclical and declining importance of inventories in GDP

This section presents analysis of the ratio of change in inventories to GDP levels in current prices for the UK and international comparisons. The analysis highlights the cyclical nature of inventories and shows

that inventory changes have become proportionately less important to GDP over time (**Figure 3**).

Figure 3 illustrates cyclical nature in the ratio of change in inventories to the level of GDP in current prices. There are significant troughs during 1975, the early 1980s and the early 1990s. It also shows a decline in the size of the cycles throughout the period. It is possible that the more stable series towards the end of the period reflects the consistent performance of the UK economy. It will be interesting to see if this trend continues amid the uncertainty of the current economic climate. However, as this graph uses annual data in order to remove the potential of alignment adjustments causing complications with international comparisons, it may be difficult to study any change in this trend in the short-term.

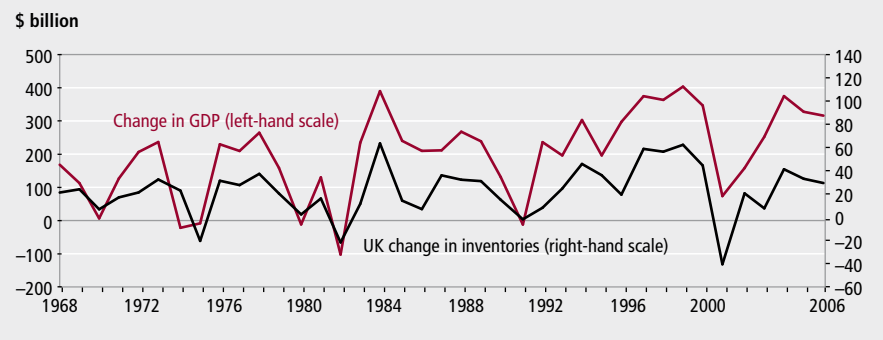
Analysis of the relationship between the change in inventories and level of GDP can be taken further by grouping the data into two time periods; pre- and post-1990. Pre-1990 represents the more volatile time period and post-1990 the less volatile period. The results show a decline in the ratio in the more recent period. Comparisons can also be made between the size of the ratios across countries. Data are provided below in **Table 2**.

The period from 1967 represents the earliest date when inventories data are available for all countries in the comparison; this table does not capture the earliest movements in the UK data. **Table 2** does, however, show that the UK data exhibit a similar degree of volatility compared with the comparison countries, with the value of the ratio of change in inventories to GDP being comparable with that of Australia and Canada and well below that of the US. Although the percentage decline in the ratio is smaller in the UK, this is partly due to the lower starting level in the early period.

Figure 4 illustrates the ratio of change in inventories to level of GDP for the US. Cyclical nature is evident for the US as it was for the UK (**Figure 3**), with the series falling below zero in 1975, 1982 (oil price shocks) and 2001 (the dot.com bubble) and dipping severely at the start of the 1990s, though not turning negative.

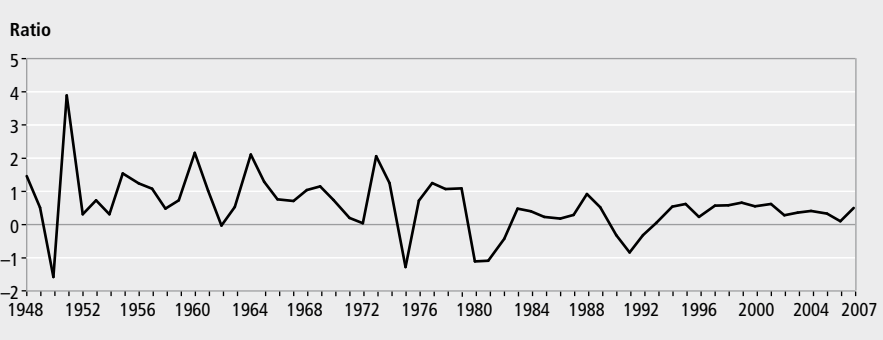
The analysis in this section shows a relationship between the change in inventories and level of GDP. It demonstrates a significant decline in the strength of this relationship over the last 10 to 15 years within the UK. Most interestingly, the international comparisons show there is a strong degree of similarity

Figure 2
GDP and inventories for the US



Source: US Bureau of Economic Analysis

Figure 3
Ratio of change in inventories to level of GDP in current prices for the UK



Source: Office for National Statistics

Table 2
Cross-country averages of the change in inventories to GDP in current prices

	UK	Australia	USA	Percentages Canada
Average since 1990	0.273	0.227	1.668	0.206
Average 1967–1990	0.374	0.476	3.682	0.428
Percentage decline	26.97	52.29	54.71	51.82

in the trends between countries and give a clear indication that the UK data are within the range of data reported by other statistical agencies.

Inventory data and its components

For the UK, change in inventories data are available for certain sectors of the economy: manufacturing, retail and wholesale (Figure 5). The series for the manufacturing and retail sectors began in 1955 and the wholesale series began in 1959. More recently, the level of detail has expanded to add the Electricity, gas and water; and Mining and quarrying sectors. The volatility and importance of the two more recent

series are minimal in comparison with the other components and the total change in inventories series; they will not be considered in this analysis.

The volatility in the aggregate change in inventories series appears to be driven by movements in change in inventories within the manufacturing sector. This is particularly evident during the major economic downturns in the UK since the 1970s. The change in inventories series for the retail sector has the largest positive correlation with the aggregate series during the period analysed. This may be surprising given the dominance of the manufacturing series during volatile periods. It is worth noting, however, that the correlation

between each of the main components to the aggregate change in inventories is strong.

The volatility of the aggregate change in inventories series has decreased since the mid-1990s; as mentioned earlier, this may be a symptom of the more stable economic growth during this period. However, if the economy experienced another period of instability, the inventories series may not be as volatile as it has been in the past. The declining importance of the change in manufacturing inventories, the most volatile component series, could mean that the aggregate change in inventories series is less reactive to the economic cycle. However, with the recent credit crisis still unwinding, it is difficult to make any strong assertions about this relationship in the short-term.

The component series for the US present a similar picture to the UK. Movements in the change in inventories series for the manufacturing sector again dominate the peaks and troughs in the aggregate series. However, unlike the UK, a significant degree of volatility is also displayed in the wholesale and retail series, which may help to explain the continued volatility of the series in the more recent period.

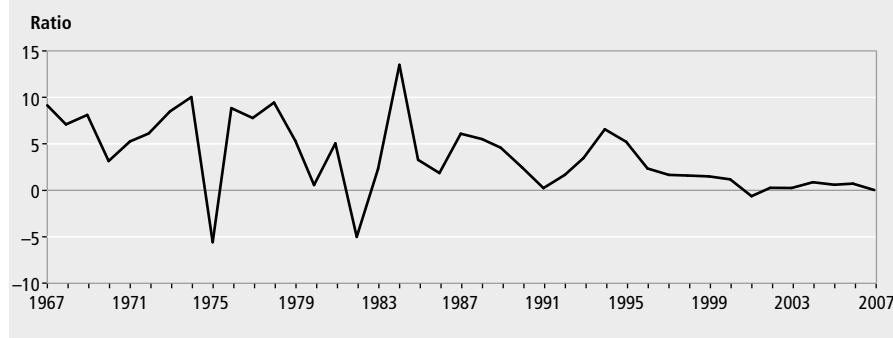
Change in inventories for the manufacturing sector by stage of production

Given the apparent importance of the manufacturing sector's change in inventories series, it is useful to analyse a further breakdown of the series. Figure 6 shows the breakdown of change in inventories for the manufacturing sector by stage of production (materials and fuel, work in progress and finished goods). The materials and fuel component appears to be dominant in the early part of the time series. After 1982, the volatility of materials and fuel series declines relative to that of work in progress, which takes over as the key driver of movements in volatile periods.

So far, the volatility of the aggregate change in inventories series has been explained by a dominant manufacturing component. This has been analysed further using the change in inventories series for components within manufacturing. The hypothesis that the decline in variability can be attributed to the changing composition of the economy away from manufacturing and towards services has been discussed earlier in the article. A further hypothesis may explain a decline in volatility within manufacturing as the composition of UK firms in this sector changes.

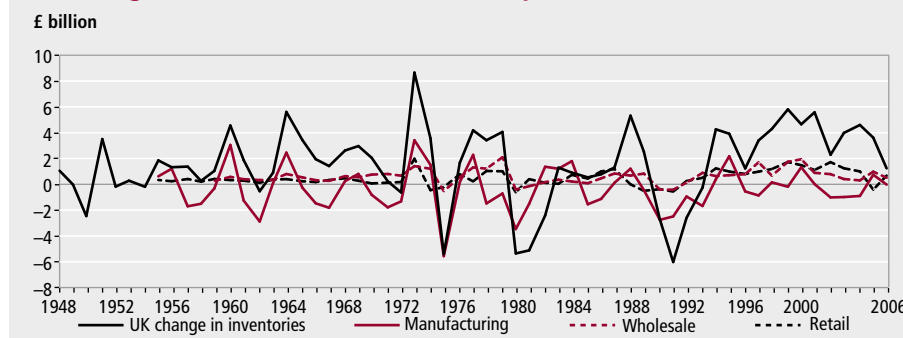
With the emergence of low-cost

Figure 4
Ratio of change in inventories to level of GDP in current prices for the US



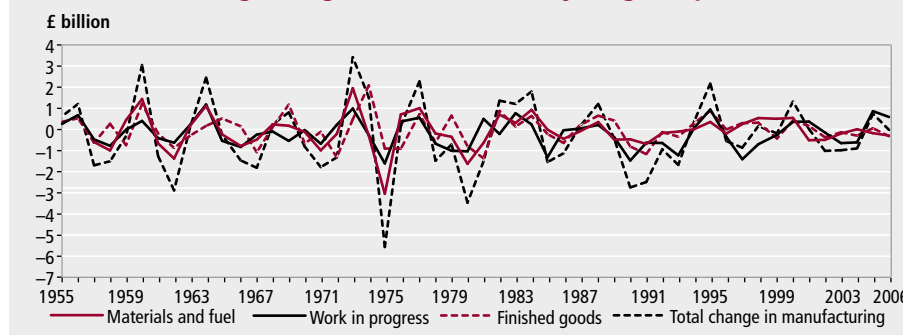
Source: US Bureau of Economic Analysis

Figure 5
UK change in inventories and main components



Source: Office for National Statistics

Figure 6
UK manufacturing change in inventories: by stage of production



Source: Office for National Statistics

economies in world trade markets, the UK manufacturing sector has had to adapt to compete, with successful manufacturing firms concentrating their business efforts in high technology/high value-added industries, competing in terms of sophistication of product rather than cost. With this in mind, it seems likely that the majority of inventory holdings in these types of manufacturing firms would be work in progress rather than stores of raw materials. This is because component parts for high value-added products are likely to be costly and therefore would probably be added straight into the production process rather than stored as inventories. If this is taken in combination with the increasing globalisation of firm activities and the proliferation of outsourcing (the movement of certain aspects of the production process abroad, for example, the production of computer components in East Asia) which might further reduce the level of materials and stores, it is possible to explain the patterns in the data.

Change in inventories data for the manufacturing sector in the US are also available in more detail (Figure 7). Consistent with the UK, the data show that the work in progress component is the dominant factor in volatile periods. However, it does not mirror the decline in volatility of materials, stores and fuel seen in the UK. This can again be argued as a perfectly plausible trend in the data; the US has not suffered the same decline in basic manufacturers as the UK, and is also a world leader in many of the high-technology manufacturing sectors. As such, the economy has a much broader manufacturing base and the degree of outsourcing in early stage production processes will be much smaller.

ONS data and external comparison

The CBI produces a variety of inventory information in its monthly and quarterly survey releases. The survey data are available for retail, wholesale and for the stages of the manufacturing production process. It is therefore possible to compare ONS estimates with those published by the CBI from 1985 onwards.

Unfortunately, the data for retail and wholesale are collected and reported on a monthly basis in the CBI survey and as such do not have the same reference period as ONS data. For the purpose of this analysis, a monthly change in inventories series was constructed from the quarterly series published by ONS. The monthly series was created by assuming a linear relationship between the two quarterly data points.

The degree of correlation between the two sets of data is virtually zero. The series do not match up to any degree and it is often the case that the direction of movement of the two series is opposite. A potential reason for this difference is in the structure of the CBI survey itself. It is not a direct measure of inventory volumes, merely a response to a survey question about the levels of stocks relative to expected demand. Respondents reply with an answer of 'high', 'adequate' or 'low' and, over the recent period, the vast majority of respondents to the survey have given the answer 'adequate'. As such, the use of this series as a comparison to the ONS estimates is limited.

In the CBI quarterly industrial trends survey, the question is a much more suitable proxy for the ONS data, asking whether 'the level of stock is up, down or the same over the last three months'; as such, it is more likely to match. The relationship between the two data sets is stronger for all subsets of manufacturing inventories, but the overall strength of this relationship

is still quite weak. The data move closely in certain time periods, but are seemingly unconnected in others. The strongest relationship is found between the finished goods series. The two series display a number of periods of strong correlation but no consistent lag or link in other time periods. This limits the conclusions that can be safely made about any meaningful relationship between the series.

The lack of coherence between the two data sources is not particularly worrying, having established a reasonably strong degree of similarity between the UK, the US and Canada. As the CBI survey is based on a balance statistic estimated from responses of a chosen panel of firms, it would only be a proxy for actual movements in inventories.

Conclusion

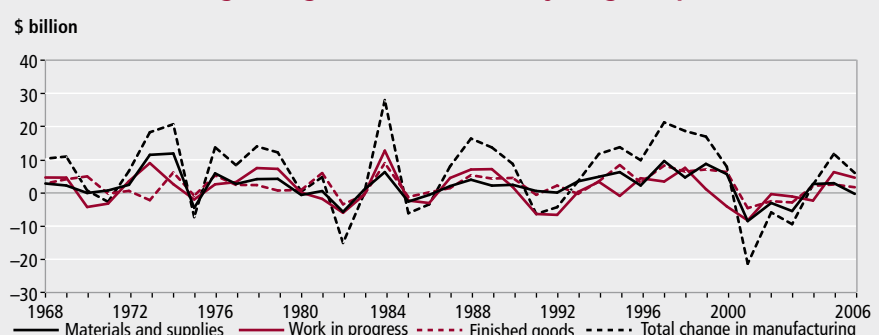
The work carried out and summarised within this article serves to highlight some of the complications involved in creating the real change in inventories data with holding gains removed. It highlights the methodological difficulties and provides a short guide to the processes involved in creating the series. The UK methodology for estimating the change in inventories is comparable with that of other national statistical agencies, following the Eurostat guidance closely. Data are available on an aggregate and industry level for the UK and are further disaggregated for various stages of the production process within the manufacturing sector. This level of detail is limited compared with the US, but provides a similar level of detail as Canada and Australia.

The main difficulties in producing inventories data are:

- accurately aggregating the sample data to a whole economy series due to the issues involved in timing of data collection and collation
- accurately deflating the series with the most appropriate set of price indices to remove holding gains from the book value figures reported
- ensuring that respondents understand the scope of the survey in order to capture the correct items from the firm's balance sheet and to identify any change in accounting practices which would affect the data

The international comparisons made in the article show that, in terms of the relationship between the change in inventories and the change in GDP and the

Figure 7
US manufacturing change in inventories: by stage of production



Source: US Bureau of Economic Analysis

patterns within the industry sectors, there is a strong degree of similarity between the UK, the US and Canada. It appears that firms behave differently in Australia, as the relationships and behaviour of the change in inventory series are often at odds with the other countries.

The patterns in the data seem consistent with the story of the economy over the recent time period; it is also reassuring that some of the patterns seen in the UK are mirrored in the US.

In the UK, there appears to be a relationship between the movements in GDP and the change in inventories, but this relationship shows signs of weakening in the recent time period. The importance of inventory movements within GDP appears to be in decline. Whether this is a symptom of the more stable economic climate, or a fundamental change in the relationship, is left as an unanswered question. However, if the recent instability in commodities and financial markets results in slower economic growth, it may be possible to provide an answer to this question in the future.

It seems clear that the movement of the UK economy away from an industrial base towards the service sector has increased

the stability within the inventories series. This is because the driving force behind many of the periods of volatility has come from within the manufacturing sector. It has been argued that the increased degree of globalisation and outsourcing during the recent past may have contributed to the reduction in volatility in the series.

This article has considered some of the key relationships within the change in inventories series in the UK and made some cross-country comparisons on trends within the data. There have been a number of suggestions put forward to explain the patterns witnessed, but there remains a great deal of work which could be carried out to provide greater insight, especially in relation to how the changing relationships within the data might impact upon future movements in the series.

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