NZIER's Capacity Utilisation Index

Bernard Hodgetts, Economics Department

The Institute of Economic Research (NZIER) produces an index of capacity utilisation from its Quarterly Survey of Business Opinion (QSBO) known as CUBO (standing for Capacity Utilisation, Business Opinion). CUBO is a useful indicator of the business cycle and inflation pressures, but its behaviour has changed over its 43-year history. The average level of CUBO fell sharply between 1974 and 1991 but has since increased again. Although that shift may be explained by economic factors, changes to the QSBO sampling framework could also be relevant. This article summarises a joint project led by the NZIER to investigate this issue. Reassuringly, it found that changes to the sampling framework do not appear to have had a significant impact on CUBO. Moreover, alternative calculations of CUBO produce a series which also shows a sharp fall over the 1974 to 1991 period.

1   Introduction

The New Zealand Institute of Economic Research (NZIER) has conducted a comprehensive quarterly survey of business opinion — known as the QSBO — since 1961. This survey asks respondent businesses a range of questions about their output, costs and prices, and employment and investment intentions. It also measures their perceptions of general business conditions. The survey data are widely used as indicators for assessing various aspects of New Zealand's macro-economy.

An indicator of particular interest is an index of capacity utilisation, known as CUBO (an acronym standing for Capacity Utilisation, Business Opinion). Capacity utilisation is a measure of the intensity with which firms are using their plant and equipment. CUBO is calculated from the responses of the manufacturing and building sectors to a question about the extent to which they could expand production without raising unit costs. CUBO is one of a range of variables that the Reserve Bank uses to help gauge the overall state of the business cycle and inflation pressures.

Although CUBO varies with the business cycle, there have also been distinct shifts in its average level over its 43-year history. The survey question from which CUBO is derived has remained unchanged over this entire period, but there have been important changes to the sampling framework. A reasonable question to ask therefore is whether the changes in the average level of CUBO over time reflect economic and structural changes, or whether they are due, even partly, to these sampling changes. This is an important issue given

the role played by CUBO in the assessment of inflation pressures.

The NZIER, the Reserve Bank, and The Treasury recently undertook a joint project to examine the extent to which the path of CUBO has been affected by changes in the survey. The project also looked at how the method of calculating CUBO may have affected its path over time. This article briefly provides some general background on how CUBO is constructed and its role in the Bank's analysis of the economy. It then summarises the results of this project, which are detailed in a fuller research report.[1]

2   What does CUBO measure?

Although there is no universally agreed definition of a firm's capacity utilisation, two general approaches are evident in the economic literature. The first focuses on the physical limits of the production process and is represented by the likes of Johansen (1968), who defines capacity utilisation as the "ratio of [a firm's] actual output to the maximum that could be produced per unit of time with existing plant and equipment".

However, this definition may not be particularly useful from an economic standpoint. Well before absolute physical constraints on production become binding, most firms will start to experience an increase in their average cost of production as output increases (assuming no change in the

---

1   Analysis of NZIER's Capacity Utilisation Index (CUBO), Report to The Treasury and Reserve Bank, NZIER, December 2003. A copy of the report can be found at www.nzier.org.nz.

level of plant and equipment used). For instance, higher average costs could arise due to the need to operate extra shifts, undertake additional plant maintenance, and so on.

An alternative approach to measuring capacity utilisation is to focus on the ratio of actual output to the level of output beyond which the average cost of production begins to rise. As noted by a number of authors, such as Berndt and Morrison (1981), this point may be best represented by the minimum point on the firm's short-run average cost curve (figure 1). Although this point is sometimes termed 'capacity output', a firm could, of course, increase output beyond this point, albeit with higher unit costs in the short term.

Figure 1

Berndt and Morrison approach to capacity utilisation
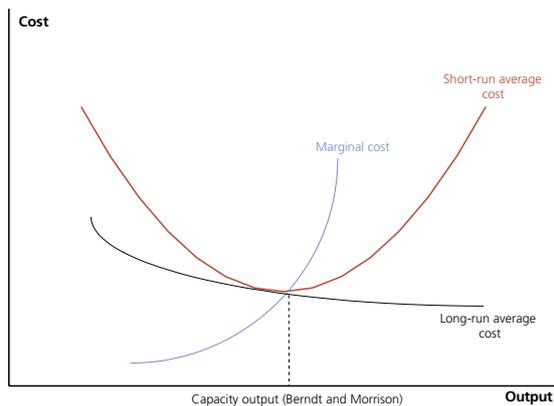
The cost-based approach to measuring capacity utilisation of Berndt and Morrison appears to correspond closely to that used by the NZIER in compiling and constructing CUBO. Manufacturing and building sector respondents to the QSBO[2] are asked:

Excluding seasonal factors, by how much is it currently practicable for you to increase your production from your existing plant and equipment without raising unit costs?

As shown in table 1, respondents are asked to tick one of five ranges representing the percentage increase in output possible before unit costs begin to rise. The data are then used in the calculation of CUBO, the details of which are shown in the Box. Figure 2 shows the full history of CUBO since the index was first compiled in 1961.

Figure 2

Capacity utilisation (CUBO)
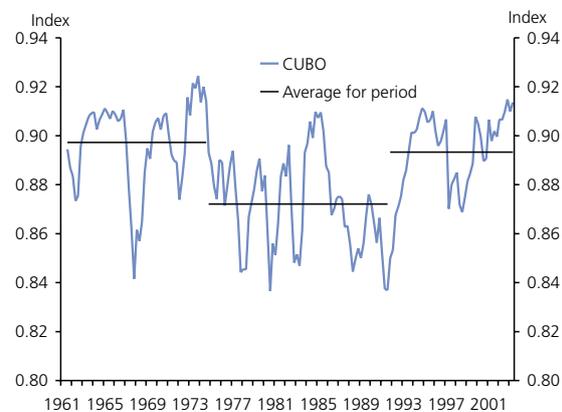
3   Use of CUBO as an indicator

As a measure of the intensity with which firms are using their plant and equipment, CUBO is a useful indicator of the business cycle. As figure 3 shows, capacity utilisation tends to rise as economic growth accelerates, and fall when growth is slowing. CUBO appears to be a leading indicator, providing a one quarter lead on changes in GDP. This correlation means that CUBO can be used to help estimate GDP prior to when the official data become available, several

Table 1

Response to capacity utilisation question – June 2003 quarter
(excludes non-responses)

% increase	0%	1 – 5%	6 – 10%	11 – 20%	Over 20 %	Total
No. responses	35	44	49	51	45	224
Per cent of responses	15	19	21	22	19	96

2   Note that there is no attempt to measure the capacity utilisation of merchants and service sector respondents in the QSBO.

Box

The Calculation of the Capacity Utilisation Index (CUBO)

Calculation of CUBO each quarter involves three steps:

- Identifying which of the five response intervals the median (middle) response sits in (non-responses are ignored). In the example in table 1, this would be the 6-10% interval.

- It is assumed that the responses in the category containing the median response are distributed evenly across the category. The value of the median response is then calculated using the following formula:

$$\text{Median} = \text{Lower limit of median interval} + \left[\frac{\dfrac{n}{2} - \text{number below median interval}}{\text{number within median interval}} \right] * \text{width of median interval}$$

where n is the number of responses. This median value represents the degree of spare capacity across manufacturers and builders. In the example in table 1, the median would be calculated as:

$$6 + ((224/2 - (35+44))/49)* 5 = 9.37$$

- The index of capacity utilisation — CUBO — is then derived by calculating the implied ratio of actual output to capacity output. Assuming actual output =100, then capacity utilisation or actual output over capacity output is equal to 100/(100+m) where m is the median value of spare capacity calculated above. So for the data in table 1, CUBO would be 100/(100+9.37) = 91.4%.

months after the end of the quarter in question. At present, the Bank maintains two types of CUBO-based indicator models as part of a wider suite of models developed to help identify the current strength of activity:

- A model that uses lagged changes in CUBO to predict the latest quarterly growth rate of GDP.

- Models that combine the lagged value of CUBO with the quarterly change in retail sales and various measures of primary export production (data for which are available prior to GDP) to predict the quarterly GDP growth rate.

Figure 4 (overleaf) shows that even the simplest of these models contains useful information about the latest quarterly change in GDP. Lagged changes in CUBO explain about 45 per cent of the quarterly change in GDP.[3]

---

3 In practice, forecasts from these sorts of models would be supplemented with additional information about activity over the quarter in question.

Figure 3

### Capacity utilisation and year on year GDP growth (CUBO is seasonally adjusted)
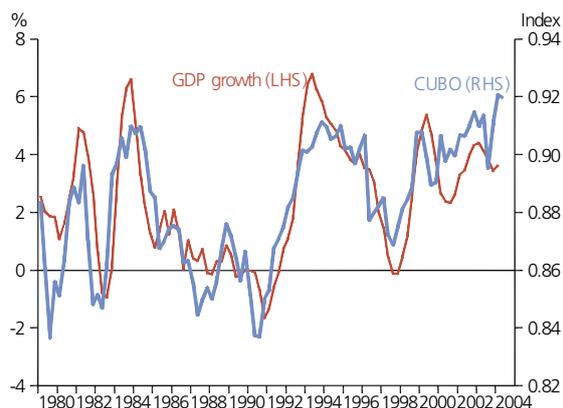
Since CUBO measures the extent to which firms are facing higher unit costs of production, it is also valuable as a leading indicator of demand-led pressures on output prices (CUBO typically has a two to four quarter lead on inflation). As figure 5 (overleaf) shows, CUBO is closely correlated with the non-tradables component of CPI inflation — a measure of inflation for goods and services mainly produced

Figure 4

CUBO-based indicator models of GDP (CUBO is seasonally adjusted)

Figure 5

Capacity utilisation and annual non-tradables inflation (CUBO is seasonally adjusted)
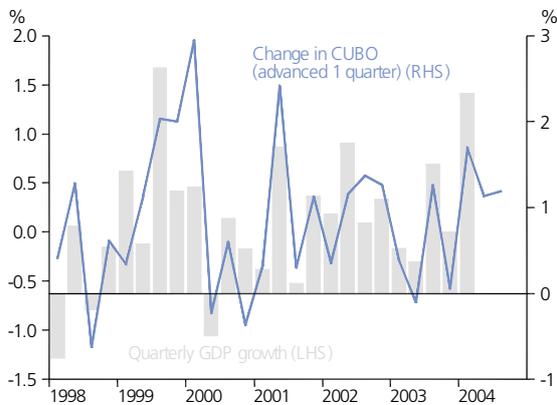
and consumed locally.[4] In the correlation shown in figure 5, movements in CUBO explain about 55 per cent of the annual change in non-tradables prices. The Bank uses this relationship to help derive estimates of the extent to which economic activity may be above its trend or potential level (sometimes called its non-inflationary level).
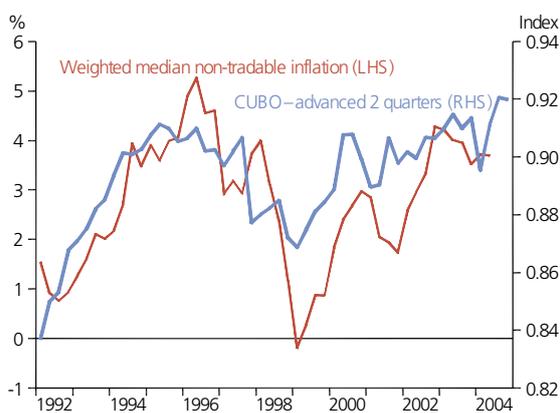
In arriving at these estimates of potential output, GDP data is filtered (ie, smoothed) to provide an initial statistical estimate of its trend. The estimate of this trend at the end of history is then 'conditioned' using the latest values of CUBO

along with other information about inflation pressures, including the extent of skill shortages in the labour market.[5] The difference between actual output and this estimated 'potential' level provides a summary measure of the degree of cyclical inflationary pressure present in the economy, and is known as the 'output gap'.

The output gap plays a key role within the Bank's Forecasting and Policy System (FPS) model. Within FPS, projections of inflation depend to a large extent on the projected evolution of the output gap over time. The assumed starting level of the output gap — which CUBO helps to determine — plays an important part in these projections.[6]

4   The NZIER Study

As noted in the previous section, CUBO is inherently cyclical in its behaviour, fluctuating over the business cycle. Over longer periods of time, CUBO may also be affected by structural changes in the economy. Changes in productivity, working patterns, cost structures, or technology could all potentially affect the average level of CUBO prevailing over time. For example, an economy-wide removal of penal rates for overtime could potentially increase the level of output possible without raising unit costs, resulting in a fall in CUBO (relative to any given level of output). In other words, the average level of CUBO could well change over time.

As figures 2 and 3 show, although CUBO clearly fluctuates throughout the business cycle there have also been distinct, long-lived periods during which the average level of CUBO has differed. The average level of the index was high from 1961 to 1974 but dropped in the period through until 1991. Since 1991, the average level has increased and has been only slightly lower than during the 1961 to 1974 period.

This shift down in CUBO from 1974 to 1991 can be given an economic interpretation. As the NZIER study notes, this was a difficult period for the New Zealand economy. It encompassed the effects of two oil price shocks, widespread economic deregulation and reforms, the 1987 share-market crash, and a severe global recession. Monetary policy was

---

4   Non-tradables inflation is less affected by world prices and exchange rate fluctuations, and therefore tends to reveal the influence of domestic demand and supply conditions more clearly than tradables inflation.

5   This variable is also surveyed in the QSBO.
6   See Reserve Bank (2003).

tightened significantly over the latter half of the 1980s, with the aim of reducing high rates of inflation at the time. Between 1974 and 1991, growth in GDP, although highly variable, averaged just 1.8 per cent per annum. In contrast, growth in both the period between 1961 and 1973 and 1992 to 2003 averaged about 3 per cent. These differences would go some way to explaining the persistently lower level of CUBO from 1974 to 1991.

However, during the 43-year history of the QSBO, there have been significant changes to the sample and range of businesses covered, as well as the methodology used to weight the results of different sized firms. A key question addressed by the NZIER (2003) study was whether the sampling and weighting changes may have unwittingly led to changes in CUBO. This is clearly an important issue for the Bank given the potential for misleading inferences to be made about the business cycle and inflation.

The initial QSBO survey in June 1961 was restricted to 100 manufacturing and building firms drawn from the pool of NZIER members at the time. Additional sectors were gradually added to the survey during the early 1960s and the overall sample size was enhanced. Survey respondents were generally larger firms, but up until 1986 no attempt was made to weight individual firms according to size — as far as the calculation of CUBO (and other survey metrics) was concerned, each firm carried an equal weight.

The NZIER conducted a significant re-sampling exercise in 1986 with the aim of including all New Zealand businesses with more than 200 staff. All firms with fewer than six employees were excluded from the sample. Other firms were selected on a probability proportional to size basis, using the number of employees to proxy size. Firms from the existing sample still responding to the survey were retained. A new weighting system was adopted whereby individual firm responses — those for large firms — were duplicated based on their number of employees. In principle, CUBO would thus tend to be influenced more by the responses of larger firms than those of smaller ones.[7]

There was a further re-sampling exercise in 1991, which saw a slightly different weighting system adopted. Firms were stratified (placed in one of several categories) based on the number of employees. The results for each stratum were weighted according to that stratum's share of total employment, to calculate the aggregate responses to the questions in the survey. This approach was retained following a further survey update in 2000.

The main conclusion to be drawn from these changes is that the 'official' CUBO series is essentially a sequence of somewhat different series. This raises the possibility of structural breaks in the CUBO series that are not due to economic factors. Statistical tests described in the NZIER study identify three likely breakpoints in the CUBO series in 1974, 1985 and 1991. The last two of these three dates correspond closely to periods when the QSBO survey was re-sampled.

To determine the effect of weighting changes, the NZIER study recalculated CUBO for the entire period since 1961 using unweighted firm responses for the entire period. As shown in figure 6, the recalculated index differs only marginally from the official published series, being just a little lower in the post-1986 period. This minor difference aside, the high-low-high pattern of behaviour shown by the official series is still clearly evident in the unweighted index. Moreover, the unweighted index continued to show the breakpoints evident in the official CUBO series when subjected to formal statistical tests.

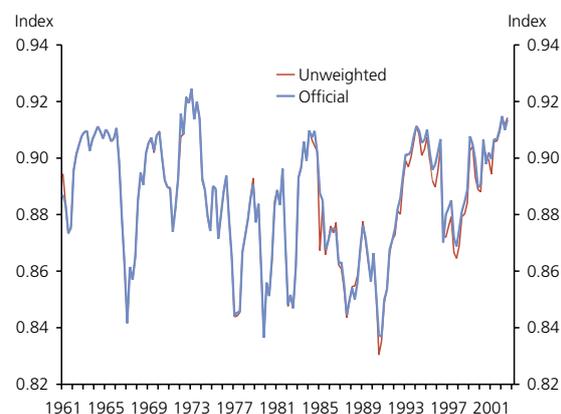Figure 6
Unweighted and official CUBO

---

7   Similarly, other survey metrics -- such as expectations of the general business outlook -- would also tend to be influenced more by the responses of larger firms following this change.

Although the above finding provides some confidence that changes to the weighting methodology used by the NZIER have had little impact on the CUBO series, there is still a question of how the process of re-sampling (the addition of new firms over time) has affected it. To examine the impact of re-sampling, the survey was divided into four sub-groups:

- The pre-1986 sample;

- The 1986 sample — the pre-1986 sample plus those added in 1986;

- The 1991 sample — the 1986 sample plus those added in 1991;

- The current sample — all firms, including those added in 2000.

Separate CUBO indices were calculated using each of these four samples and without weighting the firms by size.[8] Any differences between the series could therefore be attributed entirely to the different samples. At each of the re-sampling points, the average level of CUBO calculated using the updated sample was higher than the average level of CUBO calculated using the older sample (figure 7). However, test statistics suggested that this effect was only statistically significant when comparing CUBO calculated using the 1986 sample with that calculated using the 1991 sample.

Figure 7
CUBO calculated by sample
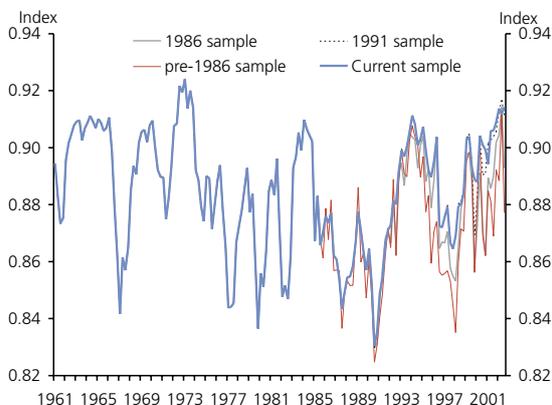
An explanation for why CUBO has a tendency to shift up at the re-sampling points may reside in a life-cycle effect. New and upcoming firms may tend to operate at higher rates of capacity utilisation than more established companies (or those potentially in decline). In support of this explanation, figure 7 shows that the CUBO index calculated for firms in the pre-1986 sample (ie, those still surveyed today) has a considerably lower mean than the series calculated using all firms in the current sample.

Another issue examined is whether changes in the proportion of different types or sizes of firms occurring due to re-sampling may have caused CUBO to alter around the re-sampling points. An earlier study by Silverstone and Hughes (1992) had found that larger firms tended to have a higher CUBO than smaller firms during the 1977-91 period. An update of this analysis by the NZIER study, however, showed that this disparity has since largely disappeared (figure 8). Moreover, at least up until the 2000 re-sample (when the proportion of larger firms was increased), the relative proportion of small and larger building and manufacturing firms has actually been relatively constant over the survey history.

Figure 8
CUBO by firm type
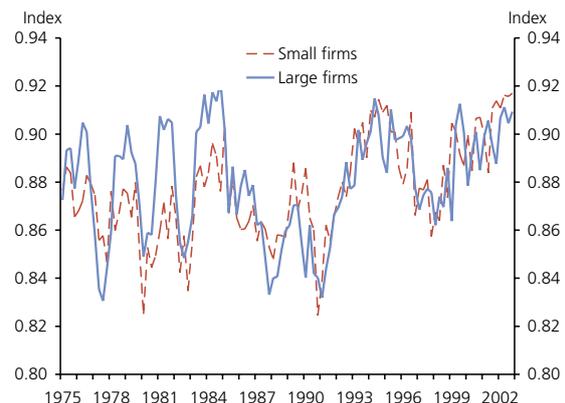
Since CUBO covers both manufacturers and builders, changes in the relative proportion of these respondents could also potentially have affected CUBO. However, that proportion has also remained relatively constant, at least until the 2000 re-sample (table 2). When separate CUBO indices are calculated for builders and manufacturing firms, differences in the indices appear to reflect differences in the

---

8   Note that at each re-sample NZIER has added new firms to the existing sample, with firms in the existing sample (and still responding) carried over. Approximately 50 firms from the original survey are still active in the survey today.

Table 2

Manufacturers and builders included in CUBO (average responses)[9]

Years	Number of builders	Number of manufacturers	Total	Builders as % of total
1975 – 86	52	148	199	26
1986 – 91	63	180	243	26
1991 – 99	62	167	229	27
2000 –	70	154	224	31

building and manufacturing cycles, rather than changes in the sample per se. However, the basic high-low-high pattern affecting the aggregate index is still evident in each of the two indices (figure 9).

Figure 9

Builders' and manufacturers' capacity utilisation
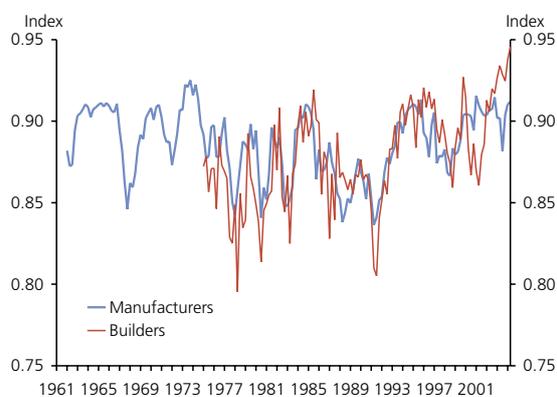
As a final check on whether re-sampling was causing the high-low-high pattern, another version of CUBO was calculated by splicing together the individual CUBO indices (calculated using the different samples). This approach corrects for any differences in the levels of the indices calculated for each subgroup at the point where they cross over. The resulting series continued to show the structural breaks evident in the official series.

## 5   Alternative methods of calculating capacity utilisation

The Box in section 2 described how CUBO is calculated based on the median value of spare capacity. The index is then generally used as if it represents the 'average' level of capacity utilisation across the building and manufacturing sectors. However, the true survey average could well

be higher or lower than the median, depending on the distribution of responses. Consequently, another issue that the NZIER study considered was the extent to which CUBO would differ were it calculated as an average.

The use of open-ended categories for the extremes of the question on spare capacity (see table 1) means that a true survey average cannot be readily established. The upper-most of the five categories captures those firms saying they could increase production by 'over 20 per cent' before experiencing higher unit costs, but the actual percentage for each firm responding in this category is unknown (eg, a particular firm might well be able to increase production by 50 per cent with no increase in unit costs). Similarly, some firms responding to the 'none' category will essentially have negative spare capacity – that is, they are likely to be already experiencing a rise in their average costs of production.[10]

One way around this problem would simply be to assume that all firms answering 'over 20 per cent' can increase production by 21 per cent and simply assign 0 to all firms

Figure 10

CUBO and a weighted average measure

---

9   Totals may not add due to rounding.
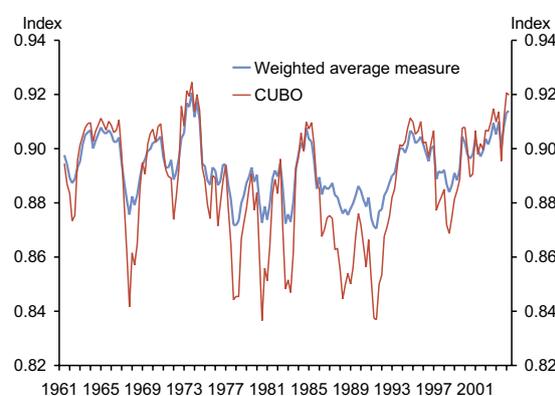
10 The use of open-ended categories could also potentially be an issue for the calculation of the median, but in practice the median never resides in these categories.

answering none. A weighted average of responses can easily be calculated. As shown in figure 10, such a series moves in a similar fashion to the official CUBO, but with less variance, particularly in downturns. This presumably reflects the limits placed on the outer categories.

A potentially better solution to the problem is to fit a distribution to the responses to the spare capacity question and, in effect, obtain estimates of these two 'tails'. Fitting a distribution is a relatively complex process, the details of which are beyond the scope of this summary article. The essence of the approach adopted by the NZIER study was to fit a lognormal distribution[11] to the spare capacity responses, extract the mean of this fitted distribution, and then use this to recalculate CUBO. Several variations around this approach were examined and are contained in the full report.

The overall finding of this work was that the alternative calculations of CUBO continued to show a similar profile to the official (median) series, albeit with a slightly different level over time. Each of these series continued to display a higher average up until 1974, before stepping down to a lower level through until 1991. Like the official series, they again step up to a higher average level after about 1991.

6   Concluding comments

CUBO plays a significant role in the Reserve Bank's analysis of inflation pressures, so it is important to be confident about the properties of this index. The NZIER study examined the history of the QSBO survey and the manner in which the capacity utilisation index is calculated. A key finding was that the behaviour of CUBO has not been significantly affected by changes in the survey sample and weighting methodology over time. Moreover, some alternative methods of calculating CUBO — for example, as a weighted average — do not appear to fundamentally alter the behaviour of the series. Although the levels of such series do differ slightly, they tend to show similar movements over time.

These findings provide some confidence about the resilience of CUBO as an indicator of business cycle and inflation pressures, suggesting that shifts in the average level of CUBO over time have been due principally to economic rather than 'methodological' reasons. In particular, the difficult economic conditions prevailing over the 1974 to 1991 period appear the most likely explanation for the lower average level of CUBO seen over that period.

References

Berndt, E and J Morrison (1981), "Capacity Utilisation Measures: Underlying Economic Theory and an Alternative Approach", *American Economic Review*, 71, 48-52

Johansen, l (1968), "Production Functions and the Concept of Capacity," *Collection Economie Mathematique et Econometrie*, 2, 46-72

Reserve Bank (2003), "An Introduction to the Forecasting and Policy System at the Reserve Bank of New Zealand," available at www.http://www.rbnz.govt.nz/research)

Silverstone, B and W Hughes (1992), "Assessing the NZIER Measure of Capacity Utilisation," paper presented to the New Zealand Association of Economists Conference, University of Waikato.

---

11   A lognormal distribution is skewed to the right and was chosen due to the skew evident in the distribution of responses to the capacity question.