Working harder or hardly working? Adjusting productivity statistics for variable capacity utilisation

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Abstract

This paper outlines the implications of adjusting productivity statistics for a variable rate of capacity utilisation of capital. Applying capacity utilisation data from the New Zealand Institute of Economic Research and occupancy rates data from Statistics New Zealand's Accommodation Survey to productivity data leads to higher capital input growth and lower multifactor productivity growth. This is a result of capacity utilisation varying and increasing over time. The paper concludes that adjusting productivity statistics for variable capacity utilisation leads to smoother MFP estimates in the short-term but has minimal impact on long-term growth.

JEL Codes: D24; O47; E22

Keyword(s): Productivity measurement; industry; capital; capacity utilisation; multifactor productivity

Introduction

Productivity measures are vital to better understand the long-term determinants of New Zealand's living standards, economic performance, and international competitiveness. Productivity is a measure of how efficiently inputs (such as machinery, computer software, and labour) are being used within the economy to produce outputs. Productivity is commonly defined as a ratio of a volume measure of output to a volume measure of input, that is:

Productivity = Output / Input

Growth in productivity means that over time, a nation or an industry can produce more output from the same amount of inputs, or the same amount of output with fewer inputs. Productivity growth can reflect changes in efficiency (getting more from given inputs), technological change, or measurement error. The key objectives of productivity measurement include:

- providing an indicator of living standards (assuming that productivity increases are matched by wage increases)
- tracing the effect of technological change
- assessing the economy's underlying productive capacity
- enabling international comparisons of productivity
- enabling assessment of policies, programmes, or economic events over time.

There are several assumptions that underlie productivity measurement (such as perfect competition, constant returns to scale, and that capital is utilised at a constant rate) that allow outputs to be meaningfully related to inputs: when these assumptions are satisfied, multifactor productivity (MFP) can be regarded as a measure of disembodied technological change. Thus, when the assumptions do not hold, it becomes difficult to meet the key objectives of productivity measurement. It is important to note that the assumption of a constant rate of capacity utilisation is predominantly relevant to capital. Variable utilisation of labour will largely be reflected in existing data.

Economic theory and alternative measurement approaches (eg Balk, 2010) can be used to address most of the assumptions required for productivity measurement (such as constant returns to scale). The one assumption of productivity measurement that theory does not provide a ready answer for is that of a variable rate of capacity utilisation. In the absence of appropriate data on utilisation rates, Statistics NZ's productivity measures assume that capital and labour are used at a constant rate over time, as recommended by the Organisation for Economic Co-operation and Development's (OECD) 2001 manual *Measuring Productivity: Measurement of Aggregate and Industry Level Productivity Growth*. Accounting for variable capacity utilisation of capital can, however, be resolved through direct application of appropriate data (for example, the New Zealand Institute of Economic Research produce a capacity utilisation series for manufacturers and builders, and a capacity as a constraint measure for services). This paper seeks to assess the impact and implications of applying a variable rate of capacity utilisation to capital services data used in productivity measures to best reflect measured-economy and industry-level productivity growth.

This paper begins by outlining the motivations for adjusting for a variable rate of capacity utilisation, the methodology and assumptions for productivity measurement, and the implications of these assumptions for MFP growth. It proceeds with an outline of data sources that can be used to adjust capital inputs for variable utilisation rates. The empirical impact on New Zealand's measured sector and selected industry MFP growth is then discussed. At the measured-sector level the impact of adjustment is minimal but evident, especially between peak years in business cycles. However, at an industry level, adjustment often leads to noticeably smoother MFP series, especially for capital-intensive industries. . The paper concludes that adjusting productivity statistics for variable capacity utilisation leads to smoother MFP estimates in the short-term but has minimal impact on long-term growth.

What is capacity utilisation and why does it matter?

Capacity utilisation reflects the difference between the potential and actual use of an input. Utilisation is highest when the most use is being made of labour and capital, and actual output is close to potential output. In a static context, capacity utilisation can refer to either 'engineering capacity' or 'economic capacity' (Shaikh & Moudud, 2004). Engineering capacity is the maximum sustained production that is possible over a period, that is, the physical potential of using inputs. Economic capacity on the other hand, refers to the desired level of output from inputs. This definition takes account of the cost of additional time units of capital or labour. In this framework, Berndt and Morrison (1981) define capacity output as the minimum point on the short-run average cost curve, where it is tangential to the long-run average cost curve. Increasing output beyond capacity is possible but brings cost pressures. In the long-term, 'full capacity' may be equated with the firm's optimal long-run equilibrium point, though 'capacity utilisation' (defined by how far actual output or variable cost is from their appropriately-defined long-run equilibrium values) may vary over time.

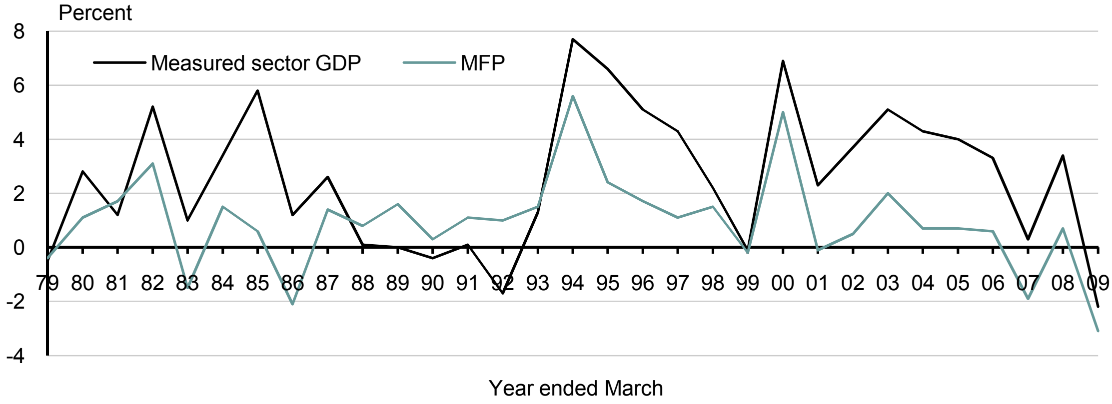
There are three key reasons for assessing the impact of capacity utilisation on MFP. Firstly, as MFP is calculated as a residual, it will include any mismeasurement of inputs, such as changing utilisation rates. In productivity analysis, capital services are assumed to be proportional to the capital stock. When an index of capital services is estimated, what is effectively calculated is a weighted average movement of the various categories of the productive capital stock. The volume of capital services which flows from a given level of capital stock is assumed to be unchanged over time (ie capacity utilisation of capital remains constant). The reality of business, however, is that capacity utilisation rates will tend to vary over time and be procyclical. As an economy experiences above-trend growth, firms will have to use their capital more intensively in the short term, since there are significant lead times associated with making investment in new capital assets, and also in bringing such investments online. This increased intensity could be achieved for example, by having factory workers work overtime (without changing the stock of capital), which would increase the volume of output without a corresponding increase in the estimated volume of input of capital services. Adjusting capital services for variable capacity utilisation overcomes the simplifying assumption (required in the absence of data) that capacity utilisation is constant.

Secondly, adjusting for variable capacity utilisation allows for greater interpretation of movements across incomplete growth cycles and between peak years. In the official productivity estimates, the methodology implicitly assumes that the rate of capacity utilisation does not alter; therefore any real-world change in the extent to which capital is utilised in production will be recorded as a change in productivity. Where the rate of utilisation is constant, estimating productivity growth over cycles is preferable, as it accounts for changes in capital utilisation rates. Where the rate of utilisation is allowed to vary, growth cycles are not necessary and the end-point problem arising from using statistical filters is overcome. In other words, average growth rates across incomplete cycles can be calculated and interpreted as though they are complete. At the aggregate level, MFP growth rates should be the same across a cycle but the growth rates for the years between the peaks of a cycle should differ.

The third reason for assessing the impact of capacity utilisation on MFP is to provide an economic understanding of the observation that MFP is procyclical. MFP rises in booms and falls in recessions (see figure 1). The role of capacity utilisation is one possible reason for this observation as capacity utilisation is also procyclical.

Figure 1

GDP and MFP
Year ended March, 1978-2009
Annual percentage change



Source: Author's calculations using Statistics New Zealand data

During periods of positive growth, firms either need to invest in additional capital and labour to meet demand, or use resources more fully (the latter is optimal if there is spare capacity and the associated marginal costs are less than those of additional investment). MFP depends on the weighted growth rates of both inputs. If input measurement does not take account of changing utilisation rates, then input procyclicality could potentially distort MFP growth estimates during both boom and bust periods. Across cycles, however, MFP growth rates should be the same with and without adjustment; the concern surrounds the fluctuations between the peaks of a cycle.

There are several economic arguments to explain why productivity is procyclical. First, technology shocks (which are reflected in MFP) may lead to output and labour input growth and therefore drive growth cycles. This is the dominant assumption underlying real business-cycle theory. Secondly, procyclical productivity may result from increasing returns to scale, that is, the economy becomes more efficient by moving to higher levels of activity. The last main argument is that if input cyclicality is routinely unaccounted for, measured productivity may be procyclical even if actual productivity does not change.

The gap between actual and measured productivity most likely comes from cyclical errors in measuring inputs such as unobserved changes in capital utilisation, or the intensity of work effort (Basu, 1996). Variations in output are reflected in the data, but the corresponding variations in the utilisation of capital inputs are not captured due to the difficulty of measurement. While intensity of effort of labour will also not be captured, changes in the intensity of use of labour inputs will to some extent be captured in the 'hours paid' measure of labour input (ie through overtime). Consequently, MFP estimates are procyclical and changes in capital utilisation are picked up by the residual productivity measure. One of the reasons for the procyclical behaviour of productivity series is that the flow of services is assumed to be a *constant* proportion of the capital stock; variations in output are reflected in the data series, but the corresponding variations in the utilisation of capital (and labour) inputs are inadequately captured. If 'machine hours' were measured, adjustments could be made to the relevant capital input data. However, in practice, the required data do not exist and consequently, swings in demand and output are picked up by the residual productivity measure (OECD, 2001).This argument was seen by Solow to be the major driver of the procyclicality of measured productivity (Basu & Fernald, 2000).

Productivity measurement and interpretation

Statistics NZ's method of estimating productivity statistics is based on OECD guidelines, as outlined in *Measuring Productivity: Measurement of Aggregate and Industry Level Productivity Growth* (OECD, 2001)[1]. The approach involves the estimation of a Cobb-Douglas production function in index form. The labour, capital, and total input series for each industry were constructed in the same manner as for the measured sector: the labour input index is a composite index of hours paid, the capital input index reflects the flow of capital services from assets, and the composite total inputs index reflects both labour and capital inputs. Productivity growth is defined as the ratio of output growth to input growth.

The calculation of industry productivity statistics begins by postulating a production function of the form:

$$V_i = A_i(t) \, x \, f(L_i, K_i(\theta_i)) \quad (1)$$

where V_i= chain-linked industry value added index

L_i = industry labour inputs

K_i = industry capital inputs, which is some function of θ_i

θ_i = rate of capacity utilisation of capital (assumed to be constant in official measures)

$f(L_i, K_i(\theta_i))$ = a production function of L_i and K_i that defines an expected level of output for a specific industry

$A_i(t)$ = a parameter that captures disembodied technical shifts over time, that is, outward shifts of the production function allowing output to increase with a given level of inputs (known as MFP).

Given the existence of index values for labour volume and value added, it is possible to calculate labour productivity for each industry as:

$$LP_i = V_i/L_i \quad (2)$$

[1] Further detail on the methodology Statistics New Zealand adopts in measuring productivity can be found in the sources and methods paper available at www.stats.govt.nz/productivity

Where LP_i = an index of labour productivity. This is a chain-linked value added index divided by a volume index of labour inputs.

Caution in interpreting the partial measures of productivity is recommended. For example, labour productivity only partially measures 'true' labour productivity, in the sense of capturing the personal capacities of workers or the intensity of their efforts. Labour productivity also reflects the change in capital available per worker and how efficiently labour is combined with the other factors of production.

The parameter that represents disembodied technological change (or MFP) cannot be observed directly. By rearranging the production function equation, it can be shown that the technology parameter can be derived residually as the difference between the growth in an index of outputs and the growth in an index of inputs:

$$A_i(t) = V_i / f(L_i, K_i(\theta_i)) \qquad (3)$$

MFP growth can arise from advances in knowledge, improvements in management, or production techniques. Certain assumptions must be met for MFP to be a measure of disembodied technological change. The key assumptions are that the production function must exhibit constant returns to scale and that all inputs are included in scope of the production function.

In practice, these conditions will not often be met and the resulting MFP residual needs to be interpreted with some caution. Given the importance of technological progress as an explanatory factor in economic growth, attention often focuses on the MFP measure as though it was a measure of technological change. However, this is not often the case. When interpreting MFP, the following should be noted:

- Not all technological change translates into MFP growth. Embodied technological change, such as advances in the quality of capital or improved human capital, will be captured in the measured contributions of the inputs; provided they are measured correctly (ie the volume input series includes quality change).
- MFP growth is not necessarily caused by technological change. Other non-technology factors will be picked up by the residual, including economies of scale, cyclical effects, inefficiencies, and measurement and misspecification errors (such as variable capacity utilisation).

The effect of variable capacity utilisation on MFP estimates

The effect of capacity utilisation on the calculation of MFP can be examined through modifying the production function to reflect a variable rate of utilisation. Assuming a Cobb-Douglas production function, then outputs can be related to inputs in log-linear form as follows:

$$\ln V_i = \ln A_i(t) + wk_i \ln(\theta_i K_i) + wl_i \ln L_i \qquad (4)$$

Where wk_i is the industry capital income weight, wl_i is the industry labour income weight, and θ_i is the rate of utilisation which lies between zero and one. Note that θ_i is applied to the volume of capital stock only and the weights are applied after this adjustment.[2] Output is increasing in the rate of utilisation, but with diminishing returns:

$$\frac{\partial \ln V_i}{\partial \theta_i} = \frac{wk_i}{\theta_i} > 0$$

[2] At the macroeconomic level, capacity utilisation is considered to be a continuous variable, but at the microeconomic level asset capacity utilisation may be binary, that is it is either used or not.

$$\frac{\partial^2 \ln V_i}{\partial \theta_i^2} = -\frac{wk_i}{\theta_i^2} < 0$$

The change in sign implies that there is an optimal level of capacity utilisation (ie less than full capacity). Beyond this point, utilising existing resources reduces output. The logic of this can be seen from its dual. The optimal capacity utilisation point concurs with the minimum point on the short-run average cost curve. An increase in output to a point greater than capacity output is associated with increasing costs of production and investment in new (and potentially relatively cheaper) capital is likely to be foregone.

MFP, however, is calculated as a residual. Therefore, any mismeasurement in capacity utilisation is reflected in MFP. Rearranging equation 1 to solve for MFP and differentiating with respect to the rate of utilisation yields:

$$\frac{\partial \ln A_i(t)}{\partial \theta_i} = -\frac{wk_i}{\theta_i} < 0$$

$$\frac{\partial^2 \ln A_i(t)}{\partial \theta_i^2} = \frac{wk_i}{\theta_i^2} > 0$$

In other words, the effect of capacity utilisation on the estimate of MFP depends on the rate of utilisation and the importance of capital. If the rate of utilisation is not constant and there are marginal increases over time from a point of utilisation less than the optimal point, then MFP will be lower than if a constant rate of utilisation is assumed. However, substantial changes in the rate of utilisation may result in a positive overall effect on MFP (as indicated by the positive sign of the second derivative). Where the same utilisation rate applies across industries, differences in MFP estimates reflect the relative weight of capital.

This approach is the most appropriate for adjusting for variable capacity utilisation. If the rate of capacity utilisation enters the model multiplicatively, then the direction of the impact of adjustment is the same as above, although the effect only depends on the rate of utilisation.[3] In this case, the effect of capacity utilisation of capital cannot be distinguished from a potential variable rate of utilisation for labour. As labour utilisation is generally considered to be well reflected in the data, this option is less applicable for empirical estimation. A further option would be to adjust both the capital inputs and capital income (which is used to weight industry capital services growth). However, the weight itself cannot be adjusted as this would violate the assumption of constant returns to scale. In addition, capital income does not need to be adjusted as it conceptually already reflects capital in use; idle capital would not generate revenue and utilisation is therefore picked up in the weight. Given these issues, equation 4 is the preferred option for adjusting for capacity utilisation.

Availability and applicability of data for adjusting for variable capacity utilisation

Adjusting for a variable rate of capacity utilisation is possible for selected industries. This section considers the applicability of possible data sources. These sources include the New Zealand Institute of Economic Research's (NZIER) capacity utilisation index and capacity as a constraint series for services, and occupancy rate data from Statistics NZ's

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3 The production function in this case can be written as $\ln V_i = \ln A_i(t) + \ln \theta_i + wk_i \ln K_i wl_i \ln L_i$

with associated partial derivatives of utilisation with respect to output:
$\frac{\partial \ln A_i(t)}{\partial \theta_i} = -\frac{1}{\theta_i} < 0, \frac{\partial^2 \ln A_i(t)}{\partial \theta_i^2} = \frac{1}{\theta_i^2} > 0$

Accommodation Survey. Transpower's transformer capacity data was considered but deemed impractical.

Guiding principles that determine the suitability of the capacity utilisation series are: the strength of the relationship between the capacity utilisation measure and output; the industry and asset scope; and the stability of the series over time.

New Zealand Institute of Economic Research's capacity utilisation index
NZIER has conducted a comprehensive survey of business opinion – known as the Quarterly Survey of Business Opinion (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.

One question in the survey addresses the intensity with which firms are using their plant and equipment: "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?" Respondents can select one of five ranges: 0 percent, 1–5 percent, 6–10 percent, 11–20 percent, and over 20 percent. This question has remained unchanged since the beginning of the survey. The 'capacity utilisation, business opinion' index (hereafter CUBO) is calculated from manufacturing and building sector responses to this question. The median value of spare capacity is calculated by identifying the median response and assuming that the responses in the median category are equally distributed. The CUBO can then be calculated as a percentage by setting actual output equal to 100 and dividing by capacity output (100 plus the median value of spare capacity).

Before 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 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. This 'economic capacity' definition of capacity utilisation corresponds closely with that used by NZIER (Hodgetts, 2004).

There are limitations to CUBO:

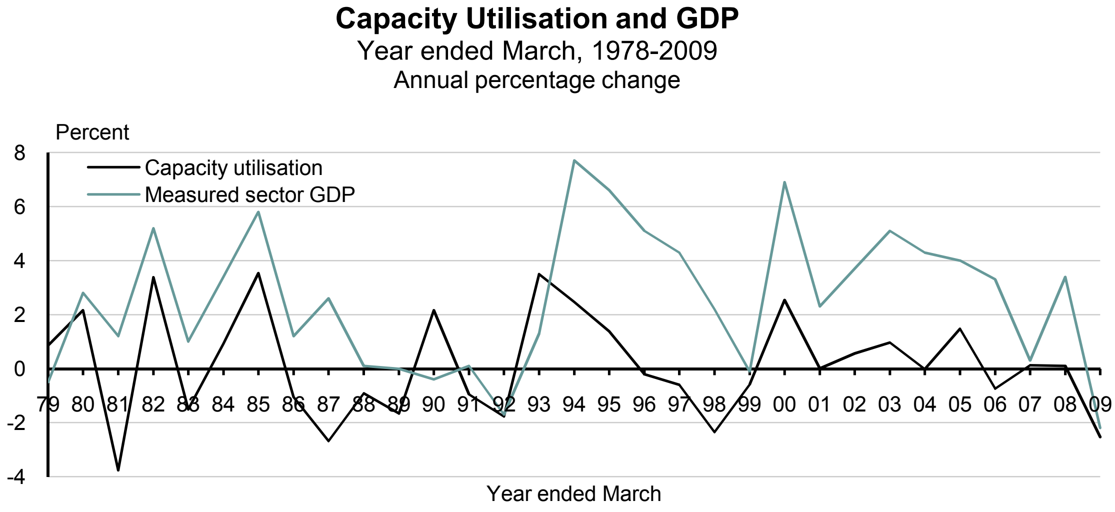
- it is limited to manufacturers and builders
- there is no capital asset dimension available (although the question in the QSBO refers to plant and equipment, it does not specify asset types).

CUBO is inherently cyclical in its behaviour, fluctuating over the growth cycle (see figure 2)[4]. 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.

Despite these limitations, there is still validity in investigating how adjusting the capital services series would affect the resulting MFP estimates by adjusting the input productive capital stock series by the CUBO ratio to approximate the ideal 'machine hour' measure of capital.

4 Quarterly data from NZIER's capacity utilisation index was converted into an annual series by taking March-year averages.

Figure 2



Source: Author's calculations using Statistics New Zealand and NZIER data

Adjusting for capacity utilisation is more beneficial if the average rate of utilisation has shifted over time. The assumption of a constant rate of capacity utilisation is reasonable from 1978–88. However, there appears to have been an increasing trend since 1988. New Zealand may be unique in this trend. Etter, Graff, and Muller (2008) found capacity utilisation in OECD countries has, on average, been trending downwards since 1970. This implies that the impact of adjustment in New Zealand may have a different effect to what it would in other countries. Comparing capacity utilisation rates across growth cycles used by Statistics NZ, it can be seen that the average capacity utilisation rate has been only mildly variable, apart from an upswing since 2000 (see table 1). Capacity utilisation has also stabilised, with the standard deviation lessening slightly over time.

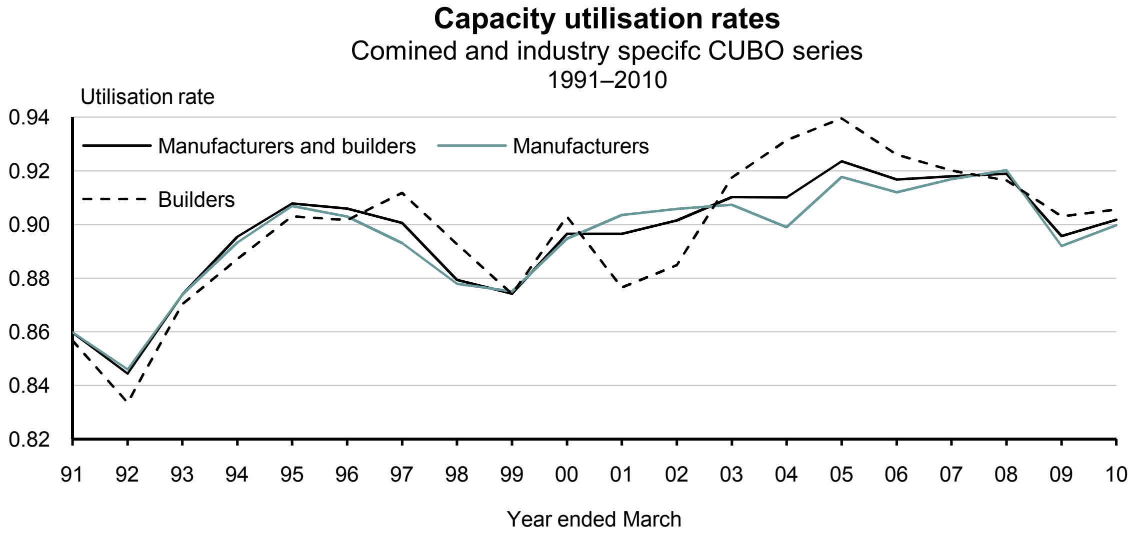
Table 1: Capacity utilisation across growth cycles

Growth cycle	Average rate of capacity utilisation	Standard deviation
1982–1985	0.88	0.02
1985–1990	0.87	0.02
1990–1997	0.88	0.03
1997–2000	0.88	0.01
2000–2006	0.91	0.01

Source: Authors' calculations using New Zealand Institute of Economic Research data

From 1991, separate capacity utilisation series for manufacturing and construction are available. Figure 3 highlights the capacity utilisation series for manufacturing and construction, and the combined CUBO. The manufacturing series follows that of the combined series closely, given the large weight for manufacturers. The construction series exhibits greater volatility than the manufacturing series. All else equal, this implies that capacity adjustment will have a greater impact on construction. As with the combined series, the level of average utilisation has increased for both the manufacturing and construction capacity series.

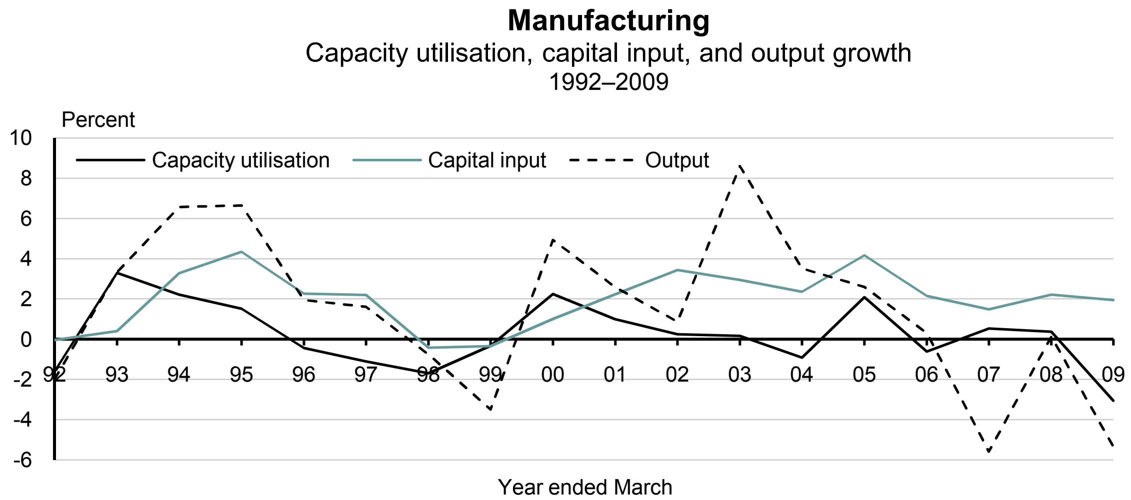
Figure 3



Source: Author's calculations using NZIER data

Figure 4 shows the movements in capacity utilisation, capital input, and output in the manufacturing industry. There is a relatively strong relationship between output growth and CUBO growth, which highlights that adjusting manufacturers capital services with CUBO is appropriate.

Figure 4

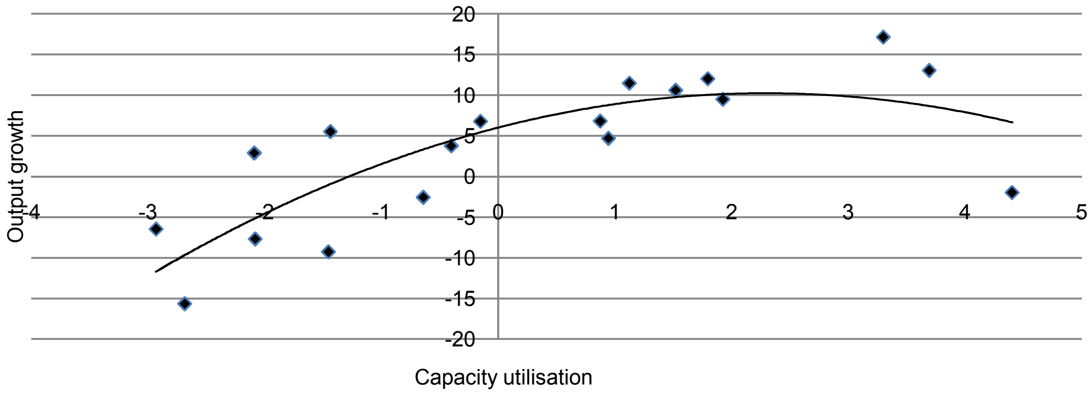


Source: Author's calculations using Statistics New Zealand and NZIER data

Capacity utilisation figures for the construction industry strongly correlate with its output growth from 1991, highlighting strong procyclicality within the capacity utilisation measure. The relationship between capacity and output is strong, although the relationship is weakened by an outlier in 1993. These observations highlight the value in using CUBO (construction) for adjustment in this industry. Figure 5 highlights the volatility in output within this industry, and the strong non-linear relationship between output and capacity utilisation (concurring with the partial derivatives of output with respect to capacity utilisation from equation 1).

Figure 5

Output growth and capacity utilisation growth
Construction



Source: Author's calculations using Statistics New Zealand and NZIER data

CUBO specifically relates to plant, equipment, and machinery assets. Capacity utilisation rates were, however, applied to all assets used in the productive capital stock in current and constant prices for the manufacturing and construction industries. This approach assumes that other assets in manufacturing and construction are utilised at the same rate as plant, machinery, and equipment.

New Zealand Institute of Economic Research's capacity as a constraint series
NZIER also produce figures for capacity as a constraint (CAAC), which are available for manufacturers and builders, merchants, services, and the total economy. Although not considered here, the merchants' series could be used to adjust for capacity utilisation in wholesale and retail trade. The CAAC series shows similar movements to those for other industries. The service sector in the CAAC series covers the activities described in table 2.

Finance and insurance, business services, and transport and storage are adequately covered by the survey and the CAAC utilisation series can be applied to the capital data for these industries. While some activity in property services, wholesale trade, and personal and other community services is covered, the coverage of the whole industry is only partial and therefore not representative. The Accommodation Survey occupancy rates data applies specifically to the accommodation, cafes, and restaurants industry and is therefore preferable to the CAAC for this industry.[5] As the CAAC data is not related to any specific asset, the utilisation rate is applied to all assets for the relevant industries.

The series is based on the percent of respondents who report that capacity is constraining. As such, it is not a direct measure of capacity utilisation. To create a rate of utilisation from this series, the CUBO series was used as a benchmark for the level of utilisation. Ordinary least squares regression was used to assess the relationship between the CAAC for manufacturers and builders and CAAC for services. The coefficient from the regression was then multiplied by the CAAC for manufacturers and builders. Then a regression of the predicted movements in CAAC for manufacturers and builders on CUBO for manufacturers and builders was run. This allows a level of utilisation to be constructed from a series of movements by rating up the CUBO series with the strength of the relationship with CAAC for services.

[5] While not directly examined, the occupancy rates data is likely to be empirically preferable for accommodation, cafes, and restaurants as it is more strongly related to the industry's output than the CAAC (see table 5).

Table 2: Relating CAAC coverage to ANZSIC96 industries			
Broad category	**Second category**	**ANZSIC96 industry**	**% of replies (April 2011 survey)**
Financial services			**12**
	Assurance and insurance	KA	3
	Auctioneer and agency	LC	1
	Banking and finance	KA	8
Professional services			**14**
	Accounting and secretarial	LC	6
	Legal	LC	8
Transport			**17**
	Passengers	IA	6
	Goods	IA	11
Customer services			**7**
	Equipment hire	LA	1
	Cleaning	LC	1
	Advertising and public relations	LC	2
	Vehicle repair and maintenance	GA	3
Restaurants/hotels			**10**
	Accommodation	HA	4
	Eating and drinking places	HA	6
Other			**40**
	Mainly business	LC	37
	Mainly personal	QA	3

The CAAC question refers to capacity in a broader sense than just capital and may pick up capacity issues relating to labour. However, as the OECD (2003) state:

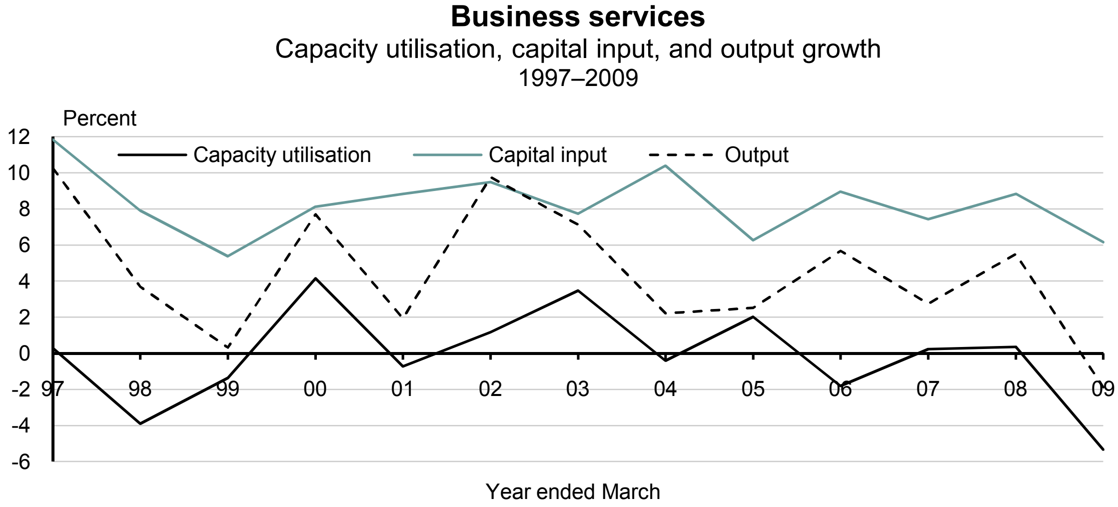
“Some respondents, however, will take account of other factors such as access to financial capital and, particularly, the supply of labour. Again this should not affect the validity of the results so far as changes over time are concerned provided that respondent behaviour is stable. However, survey data on the actual levels of capacity utilisation will represent some unknown mixture of capital and labour utilisation.”

This implies that the rate of capacity utilisation could be applied to the weighted capital input index. However, for consistency with other measures (and that it is still assumed that labour utilisation is adequately captured in the labour input series) the CAAC series enters the model as per equation 1. The CAAC series aligns with output from the three relevant service industries to varying degrees. The relationship is strongest for transport and storage from 1978–2009 but near zero for finance and insurance. For both these industries, the correlation improves from 1997. This coincides with the introduction of firm level weightings within the QSBO in 1986.

Table 3: Pearsons correlation coefficients between capacity as a constraint and industry output			
	Transport and storage	Finance and insurance	Business services[6]
1978–2009	0.40	0.01	…
1997–2009	0.67	0.28	0.60
Symbol: … not applicable			

As an example, figure 6 highlights the change in output, capital input, and capacity utilisation in business services. The industry has shown both strong capital input growth, and strong output growth since 1997. Capital utilisation has been relatively well correlated with output over the series.

Figure 6



Source: Author's calculations using Statistics New Zealand and NZIER data

It is important to remember that the CAAC utilisation series, as used here, is a derived measure. As such, the level of utilisation may not reflect the true level of utilisation. While the relative change in the derived series reflects the movements in the raw CAAC series for services, this measure would have limited use from a level perspective.

Accommodation Survey occupancy rates data

Statistics NZ's Accommodation Survey contains data on occupancy rates (total, total excluding holiday parks, hotels, motels, backpackers, or holiday parks) from the September 1996 quarter. Occupancy rates excluding holiday parks is the series used for capacity utilisation adjustment. This is the headline occupancy rate measure in the Accommodation Survey. Occupancy rates are a derived measure, calculated as stay unit nights occupied divided by stay unit nights available. Unlike the CUBO or CAAC, this series is based on actual data rather than business opinion.

Accommodation accounts for approximately 33 percent of the whole industry based on current price sales figures from the Retail Trade Survey. Ideally, the series would be applied to this sub-industry only, but as productivity statistics are not currently compiled at this level it could not be applied to this specific sub-industry. Some correlation, however, between capacity utilisation for the cafes and restaurants and accommodation sub-industries can be expected as the output series for these sub-industries are highly correlated.

[6] Productivity data is only available from 1996 for the business services industry.

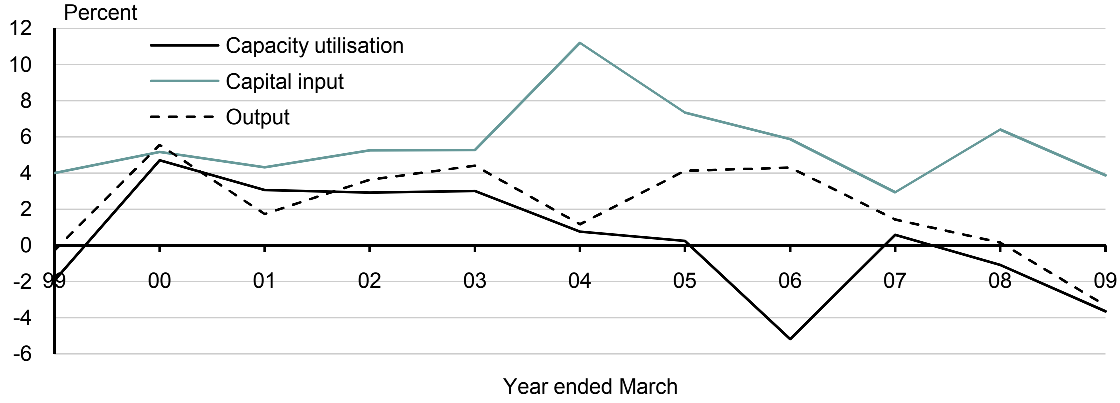
There is a relatively strong relationship between capacity utilisation and output in accommodation, cafes, and restaurants. This association is, however, strongly weakened by an outlier in 2006 (see figure 7). From 1997 to 2004, there was a general increase in the occupancy rate series, but it declines after 2004. This turning point reflects the increased investment in the industry in 2005, with the capacity of available unit nights increasing by 13.2 percent, while the number of guest nights increased by 5.5 percent (Statistics NZ 2011c). This increase in available unit nights caused the occupancy rates to flounder during this year but reflects the accumulation of capital for future use.

If there are particular shocks to an industry, in this instance a major increase in supply over demand, then the capacity utilisation measure may not be completely reflected in the capital input series due to the different treatment of investment in the two series.

This series was constructed as annual March-year averages and applied to all assets in the productive capital stock for the accommodation, cafes, and restaurants industry. As with the application of CUBO, this approach assumes that other assets within the industry are utilised at the same rate.

Figure 7

Accommodation, cafes, and restaurants
Capacity utilisation, capital input, and output growth
1999–2009



Source: Author's calculations using Statistics New Zealand and NZIER data

Transpower's electricity transformer capacity data
Capacity utilisation data for electricity, gas, and water supply is available from Transpower (released under The Electricity (Information Disclosure) Regulations 1999). Capacity utilisation refers to maximum demand as a percentage of total transformer capacity (maximum continuous ratings) and is available from 2002. Onan ratings data are available back to 1997.

As electricity cannot be stored on a large-scale basis, supply and demand in the industry are determined on a moment-by-moment basis. This is very different from other industries where inventories of output can be accumulated (Dupuy, 2006). At any one time, both the utilisation of capital and the demand for output can fluctuate widely due to the volatility of consumer demand and the uncertainty of supply due to weather conditions. This implies that there should be a very strong relationship between output and capacity utilisation.

The application of this capacity utilisation measure is problematic. Firstly, it would need to be applied to the specific electricity generation sub-industry, as the measure has no association with gas or water supply. Secondly, the relationship between output and capacity utilisation is virtually non-existent. For these reasons, assessing the effect of adjusting the productive capital stock for the electricity, gas, and water supply industry with this series has not been considered further in this paper.

Empirical analysis

To empirically account for variable capacity utilisation, constant price productive capital stock figures were multiplied by the rate of utilisation. Current price productive capital stock figures were also adjusted in this manner in order to keep the price term (calculated as the ratio of current to constant prices) in the user cost of capital constant. As no further assumptions on asset depreciation or the real rate of return were made beyond those already in the model, this means that the user cost of capital is assumed not to change with variable utilisation. In utilising all of the available data sources, it is possible to adjust productivity statistics for a variable rate of capacity utilisation for 43.3 percent of the total economy (which is 53.8 percent of the measured sector).

From equation 4, adjusting for variable capacity utilisation will impact on MFP growth with the effects greatest for capital-intensive industries. It is expected that a smoothing effect will occur to MFP estimates, as capital inputs (and therefore total inputs) become more cyclical following adjustment. Movements are likely to be dampened as adjusted capital input, and total input, more closely follows the cyclical nature of output.

Productivity estimates were derived for both a constant rate of utilisation (the base case) and a variable rate of utilisation. Base case data are consistent with those published in the latest official productivity release (Statistics NZ, 2011a).

Impact of adjustment on the measured sector

The different measures of capacity utilisation all produced slightly different impacts on the measured sector when capital input was adjusted. Because the different measures of capacity utilisation have differing time series lengths, 1998 was chosen as the starting point for much of the measured sector analysis. This was the first year where all measures were available. Analysis was also carried out on the impact of the individual capacity utilisation measures on the measured sector, specifically to look at the impact of adjusting for variable capacity utilisation over a longer time period. The manufacturing and construction specific CUBO measures were used from 1991, but prior to this, both industries were adjusted using the combined CUBO measure. Each of the capacity utilisation measures, their time series, and industries they are applied to, are noted in table 4 below.

Table 4: Summary of capacity utilisation measures

Capacity utilisation measure	Years applied	Industries adjusted
CUBO	1978–1992	Manufacturing; construction
CUBO – industry specific	1992–2010	Manufacturing; construction
CAAC	1978–2010	Finance and insurance; Transport and storage; Business services.
Occupancy rates	1999–2010	Accommodation, cafes, and restaurants

Although the capacity utilisation measures are relevant to different industries, each individual measure of capacity utilisation has a fairly high correlation with measured sector GDP growth. This implies that the combination of measures may have some impact on measured sector MFP estimates. It also implies that the procyclicality of MFP is partly a result of capacity utilisation.

Table 5: Correlations between capacity measures and measured sector GDP	
Correlations with measured sector GDP	
CUBO	0.76
CUBO – Manufacturing (1992–2010)	0.69
CUBO – Construction (1992–2010)	0.71
CAAC	0.75
Occupancy rates (1998–2010)	0.81

Impact on measured sector input

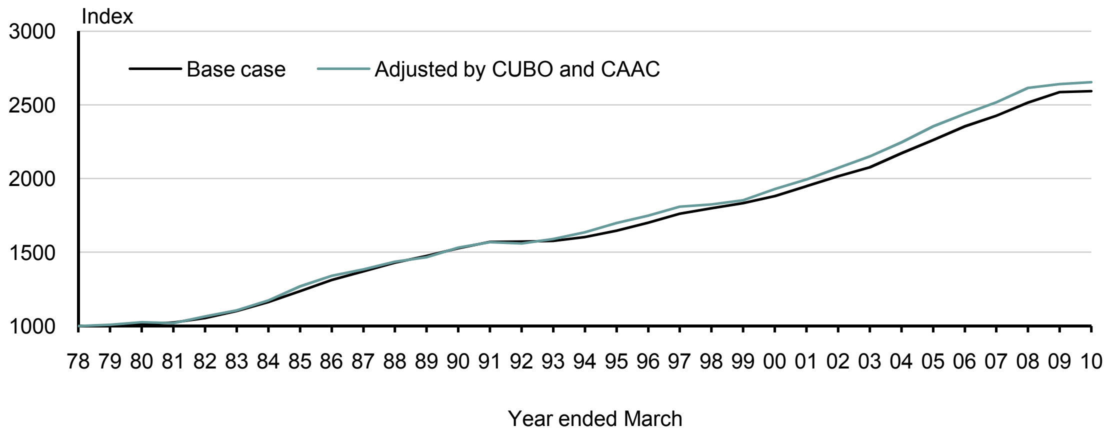
In all cases, capacity adjustment led to an increase in capital input growth for the measured sector. From the mid-1990s, capacity utilisation (CUBO and CAAC series) showed a slight level-shift upward, resulting in stronger growth in utilised capital services in the second half of the series compared with the first. This implies that capital services are understated when the utilisation rate increases. Interestingly, the points of divergence between the adjusted and base series for capital input occur at the same time as major economic events; for example, the 1992/3 recession and the Asian financial crisis in 1999 both resulted in the adjusted series diverging from the unadjusted series (see figure 8).

Figure 8

Measured sector capital services index

With and without capacity adjustments

1978–2010



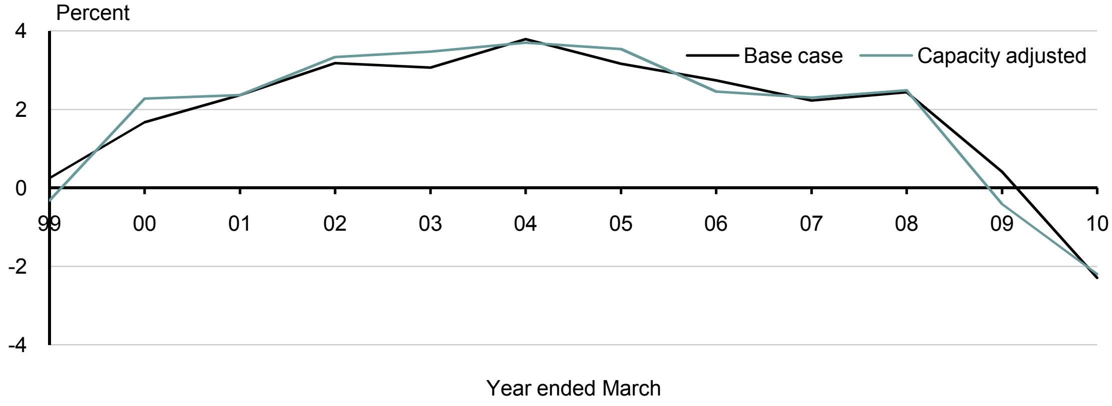
Source: Author's calculations using Statistics New Zealand and NZIER data

The impact of capacity adjustment (CUBO, CAAC, and occupancy rates) also alters the depiction of the economy during the recent economic downturn. Statistics NZ's (2010a) *Productivity Statistics: 1978–2009* information release states "Although capital productivity declined sharply in 2009, it is possible utilisation of capital was at a low point. …Under conditions where utilisation of capital is lower than average, growth in capital inputs may be artificially high and therefore growth in capital productivity may be artificially low." This scenario is implicitly observable in figure 8. After adjusting for capacity, capital input growth remained relatively flat (up 1.0 percent per year), and grew considerably slower than the base series (up 2.8 percent per year), leading to a smaller fall in capital productivity growth.

As capacity adjustment has led to an increase in capital input growth, there has also been an increase in total input growth (figure 9). The impact on the measured sector depends on the size of the adjusted industries, their capital intensity, and movements in capacity utilisation.

Figure 9

Measured sector total input growth
Annual percentage change, with and without capacity adjustments
1999–2010



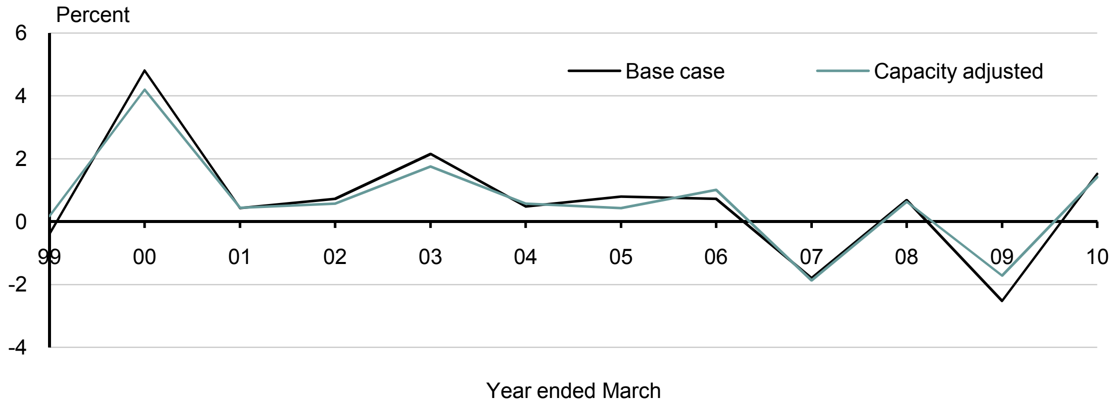
Source: Author's calculations using Statistics New Zealand and NZIER data

Impact on measured sector MFP

Measured sector MFP shows slightly smoother movements when adjusted by all three capacity measures (see figure 10). This effect is highlighted by growth in base case MFP being stronger than growth in adjusted MFP during times of positive growth, and declines in base case MFP being larger than adjusted MFP during periods of negative growth. The smoother capacity adjusted MFP index reflects the procyclicality of capacity utilisation – in times of growth more capacity is utilised, and vice versa. It also shows that the series converge over the long-term. These observations concur with the expectation that while capacity adjustment may not have much impact in the long-term, it improves MFP estimates between peak years.

Figure 10

Measured sector MFP growth
Annual percentage change, with and without capacity adjustments
1999–2010



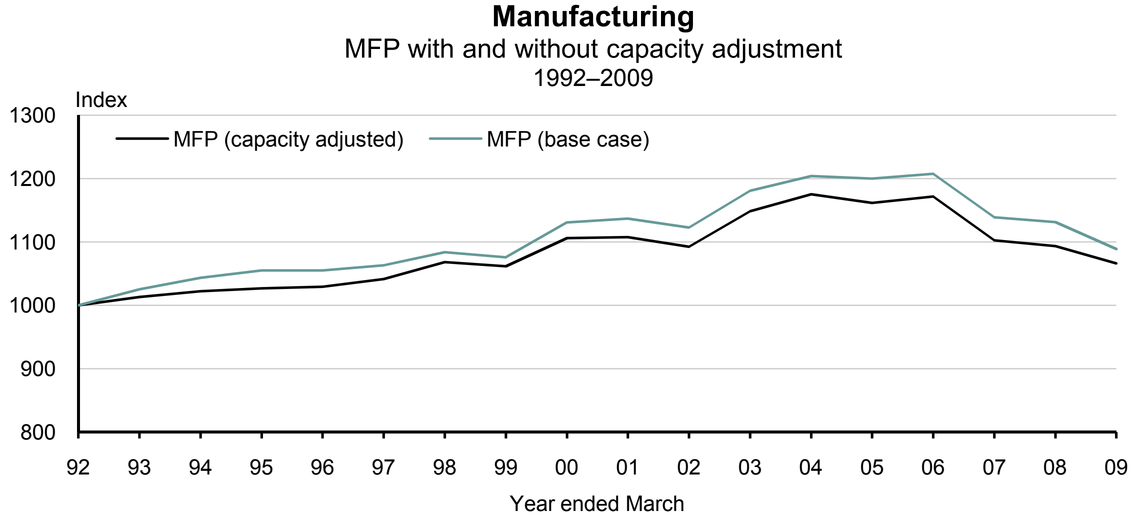
Source: Author's calculations using Statistics New Zealand and NZIER data

Impacts on industry-level MFP growth

Manufacturing

Using the CUBO for manufacturers series to adjust for a variable rate of capacity utilisation results in lower MFP growth across the series (see figure 11)[7]. The adjusted series and base case diverge slightly over the course of the series reflecting the upward level shift in the capacity utilisation series. MFP from 1992–2009 increased at an annual average rate of 0.5 percent without adjustment and 0.4 percent after adjustment.

Figure 11



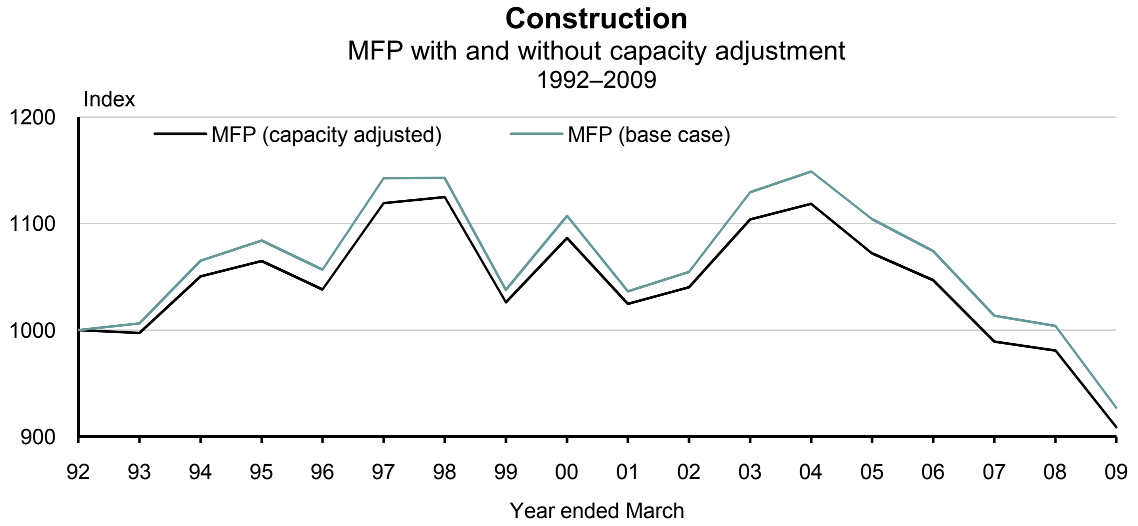
Source: Author's calculations using Statistics New Zealand and NZIER data

Construction

Although construction is a highly labour-intensive industry, capacity adjustment may have an effect on its MFP growth due to the level-shift in capacity utilisation towards the end of the series. Adjusting for capacity utilisation in construction increased the decline in MFP growth from -0.4 percent per year to -0.6 per year from 1992–2009. Adjusting for variable capacity utilisation has generally smoothed the year-on-year MFP movements, decreasing the magnitude of movements in most years (see figure 12). Note that construction is very highly labour-intensive, so the impact of adjusting capital for variable capacity utilisation on MFP is quite large given the low share of capital in this industry. This is due to adjusted capital services growing at a much faster rate than the base case. This is caused by the rate of capacity utilisation growing faster than base capital services, therefore, adjusted capital services (and total input) growth increase when adjusted.

[7] Note here that this is one of the limitations with capacity adjusting a growth series. If the base year capacity utilisation is particularly high then MFP will appear stronger over the series, and vice versa.

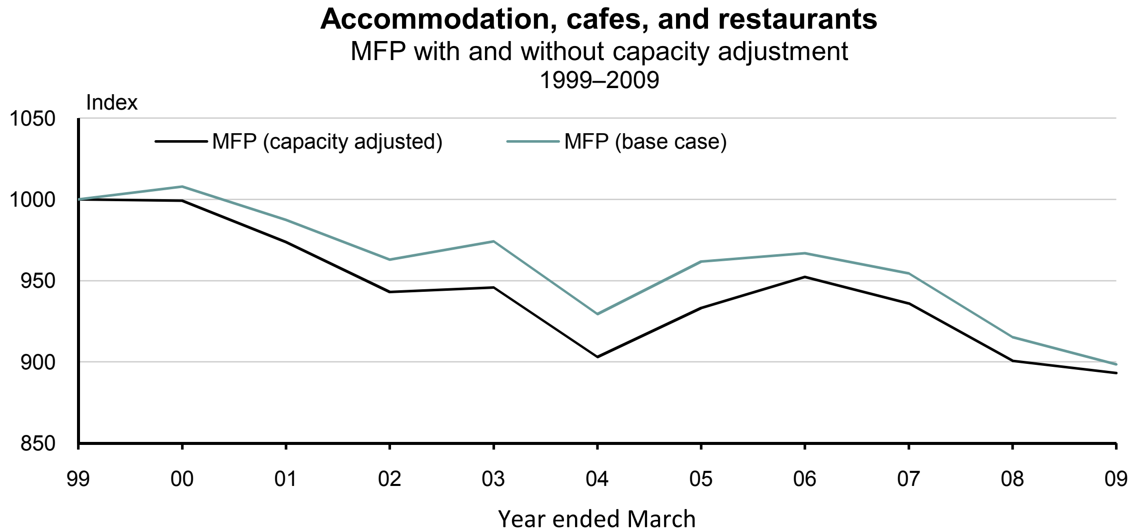
Figure 12



Source: Author's calculations using Statistics New Zealand and NZIER data

Accommodation, cafes, and restaurants
As a highly labour-intensive industry (labour income share averages 0.77 from 1978–2009) capacity adjustment may not have much impact on long-term MFP growth in the accommodation, cafes, and restaurants industry. In addition, the capacity utilisation series was at the same level in 2009 as it was in 1997. However, the series has shown noticeable variation between these years which may affect annual growth rates. Over the adjusted period, MFP declined at the same rate (down 1.1 percent per year) under the base case and after capacity adjustment. However, while there is a negligible impact over the long-run, capacity adjustment does affect year-on-year growth rates between cycle peaks (see figure 13).

Figure 13

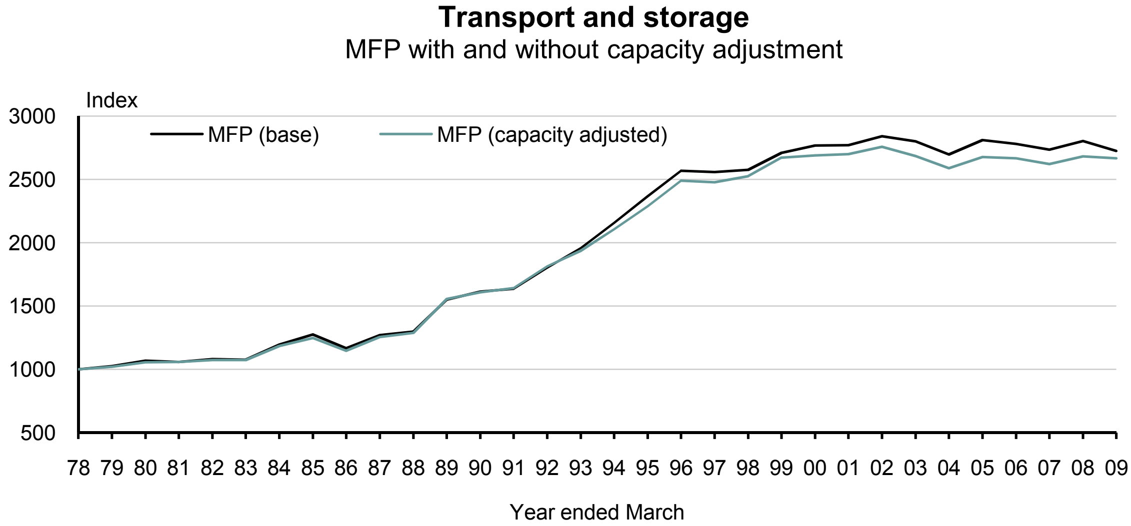


Source: Author's calculations using Statistics New Zealand data

Transport and storage
The CAAC measure is most strongly correlated with output in transport and storage. This implies that comparing MFP estimates before and after adjustment is more appropriate for this industry. MFP with and without adjustment tracks similarly until the mid 1990s, after which, the series diverge marginally (see figure 14). From 1978–2009, MFP with capacity

adjustment grew at an annual average rate of 3.2 percent compared with 3.3 percent without adjustment.

Figure 14

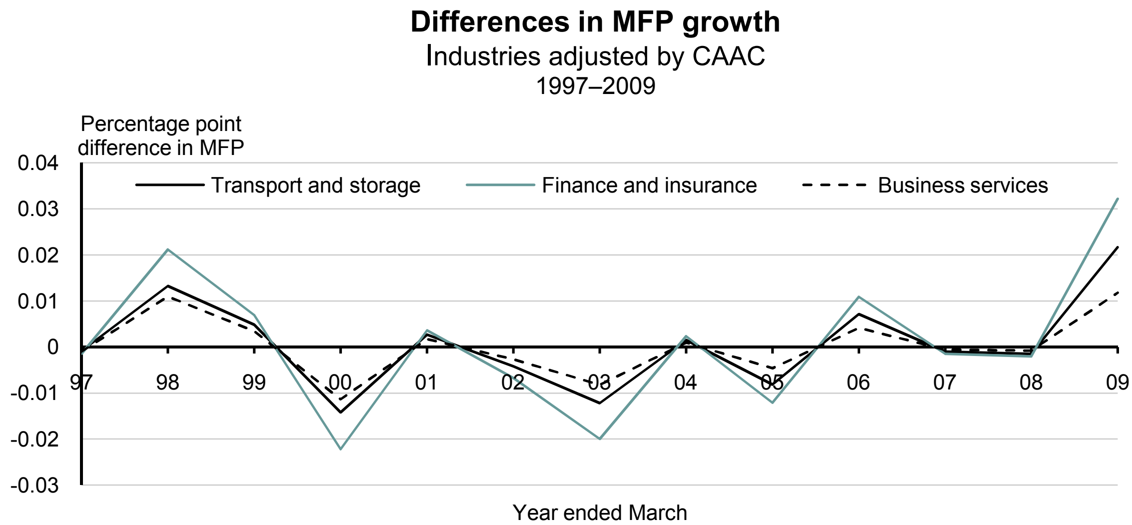


Source: Author's calculations using Statistics New Zealand data

Service industries adjusted using CAAC

Differences in MFP growth across industries which are adjusted according to the same capacity utilisation series reflect relative capital intensity. Using CAAC to adjust for capacity utilisation has a greater effect on the finance and insurance industry, followed by transport and storage, and then business services. This reflects the relative degrees of capital intensity across these industries (see figure 15) and implies that adjusting for capacity utilisation is of most benefit for capital-intensive industries. Note that in some cases the differences in MFP are positive; this reflects very strong movements in CAAC.

Figure 15



Source: Author's calculations using Statistics New Zealand and NZIER data

Conclusions

This paper has assessed the impact of adjusting official productivity statistics with independently derived measures of capacity utilisation of capital to best reflect measured-economy and industry-level productivity growth.

Adjustment can potentially improve the reliability of estimates by removing the problematic assumption of a constant rate of capacity utilisation of capital. It eliminates end-point interpretation problems that arise from applying statistical filters to determine growth cycles. If the assumption of a constant rate of capacity utilisation of capital can be addressed, then it is possible to look into long-run trends above and beyond growth cycles. Accounting for a variable rate of capacity utilisation means that productivity estimates for years at the end of the series are more meaningful and relevant, and provide more information about MFP growth between and outside growth cycles. This allows for more timely productivity measures (as the end-point becomes more meaningful for analysis), which is important for policy in times of economic uncertainty.

The empirical analysis in this paper indicates that capacity adjustment will have some effect on long-term MFP growth patterns but the effect is mainly seen across shorter-term periods. By eliminating the need for productivity analysis across cycles, capacity adjustment can also aid productivity comparisons across countries with different economic cycles. Adjusting for capacity is also advantageous when making international comparisons of productivity, because such comparisons are problematic when growth cycles differ across countries.

The assumption of a constant rate of utilisation, used by Statistics NZ, follows OECD recommendations. No international statistical agency adjusts capital services series with a variable rate of utilisation. This facilitates international comparability of productivity statistics. Adjustments could, however, be made across countries. Capacity utilisation data is routinely collected through business tendency surveys and are comparable through a harmonised system (OECD, 2003). These surveys, by asking firms about their abilities and expectations, provide qualitative data that cannot be collected through quantitative surveys.[8] For the United States, capacity utilisation data are also available from the Survey of Plant Capacity, and the KOF Swiss Economic Institute collects data for Switzerland.

Although not assessed in this paper as Statistics NZ does not currently produce productivity levels series, the levels of MFP or capital productivity are also likely to be affected by capacity adjustment. The analysis in this paper focused on the movements in utilisation and the level of utilisation is inconsequential. In a levels series, the level of utilisation is crucial. A capacity-adjusted levels series would potentially highlight the inefficient use of capital across industries by showing potential spare production capacity. Further assessment of these measures would also be required, as different criteria would need to be satisfied for application to a levels series.

A shortcoming of this analysis is that capacity utilisation measures have been applied at the whole industry level, where, in fact, adjustments should only be made to appropriate sub-industries (eg capacity adjustments should only be applied to the accommodation component of accommodation, cafes, and restaurants). It may be possible to address this shortcoming in the future as a feasibility study into further disaggregation is currently underway at Statistics NZ. Further investigation could consider the specific assets that firms consider for capacity utilisation in the CUBO, and whether this aligns with the stock of capital assets from national accounts.

[8] An alternative to using business tendency survey data would be to estimate capacity utilisation using econometric techniques (Shaikh & Moudud, 2004). This approach has been found to provide robust estimates and requires data only on capital stock and output.

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