Capital Stock Conference
March 1997
Agenda Item III

CONFERENCE ON MEASUREMENT OF CAPITAL STOCK

Canberra 10-14 March 1997

Capital Stock Measurement in New Zealand

National Accounts Division
Statistics New Zealand

Background

1. New Zealand does not produce official capital stock (or productivity) measures. By official is meant series published by Statistics New Zealand, the Government department responsible for the production and dissemination of official statistics. To date, economic analysts have either made use of an unofficial capital stock series produced by Prof. Bryan Philpott, Victoria University of Wellington (expanded on below) or variants of it (for example, altering deflators, service lives etc.).

2. Philpotts series, which are based on the perpetual inventory method (PIM), were first released in the late 1970s and have been regularly updated incorporating the latest official capital expenditure data contained in the published national accounts. The series are readily accessible and the methodology transparent, which has contributed to their wide use. Nevertheless, their acceptance is not universal - hence the alternatives produced by other analysts - and it is largely acknowledged that while they represent the best series available, there are deficiencies which restrict use. One of the implications of this is that in New Zealand there is limited consensus on the course of changes in productivity over the last few decades.

3. In response to this situation, Statistics New Zealand is soon to begin developing official gross and net capital stock measures. Research to date - largely based on examining overseas practices - suggests that the assumptions required to produce PIM based series significantly affect the final measures, so much so that when compared with data obtained by direct surveys, their validity is questioned. However, given that an historical time series is required (and the budget constraints), PIM methods either solely or in conjunction with direct surveys are likely to be adopted. Determining an appropriate methodology is the first goal.

The Philpott Capital Stock Series

4. Purpose: Philpott has used the PIM to estimate capital stock as part of an ongoing research programme on New Zealand's macroeconomic performance. Although the prime purpose of the series has been as an input into production functions and in analysing productivity - and hence the focus has been on producing gross capital stock measures which assume the productive capacity of an asset continues undiminished until it is retired - he has also produced complementary net capital stock series.

5. Published series: Annual real net and gross capital stock series from 1949/50 The series are for March years, hence 1949/50 refers to the year ending March 31 1950. to the present. Only two asset types are identified: 'buildings and structures' and 'plant and equipment'. The series are analysed by 22 industry (NZSIC) groups.

6. Data: In the absence of official series pre 1971/72, Philpott has from various sources established a database of nominal gross fixed capital expenditure and price indexes for the two asset types. The series begin in 1949/50 and are linked to the official series at their relevant 'starting' years, 1971/72 for capital expenditure and 1977/78 for the price indexes. For post 1977/78 years, published nominal and real investment series are used . Although these are available for six asset types (residential buildings, non-residential buildings, other construction, transport equipment and plant, machinery and equipment)

they are then aggregated to the two asset types for use in the PIM. Real gross investment series are derived by deflation.

7. Methodology: The PIM is used. Key aspects / assumptions are:

- Opening 1949/50 capital stock values. With a number of exceptions, these are largely derived by adjusting the historical book values ex balance sheets from company accounts and other sources. For manufacturing industries only, Philpott has available real capital expenditure series from 1910 and he uses this to construct a PIM based gross capital stock measure as at 31 March 1950, valued in 1949/50 prices. This provides an age profile of manufacturing capital stock. It is also then compared with the depreciated historic cost of assets for manufacturing as at 31 March 1950, and the ratios 1.5 for buildings and construction and 2.0 for plant and equipment obtained. These ratios and the age profiles are then assumed to hold across all industries and are used to adjust historic book values to a real gross capital stock equivalent for each industry group. This assumption implies that the rate of asset price change and the pace of investment over the 1910 -1950 period was fairly common for all industry groups in the economy.

- Average asset lives and mortality distributions. Philpott mainly uses OECD average asset service life estimates given in various OECD publications. These are 40 years for buildings and structures and 16 years for plant and machinery. Mortality functions were chosen so that assets begin to be retired 20% earlier than their average life and this continues until 20% after their average service life. In both cases, minor variations are made for specific industry groups. The average service lives have reportedly been found to be consistent with service life data recently collected via survey by the Inland Revenue Department when it reviewed depreciation rates in 1992. There appears to be no supporting evidence for the chosen mortality function.

Comments on PIM and the Philpott series

8. In 1993, Statistics New Zealand contracted a private research organisation, Integrated Economic Services (IES), to make recommendations on the development of productivity measures in New Zealand. As part of this work they investigated current practices used by a number of OECD countries to compile capital stock measures and their report Lepper J. & Simons P., *Productivity Measures For New Zealand - The Final Report* , 1993 (unpublished SNZ internal document) commented on a number of weaknesses with the PIM. While these weaknesses have been well documented in the literature, a number are repeated below as a useful summary of the issues which SNZ must resolve before proceeding with the development of PIM based estimates. It is worth noting that the independent report considered that the weaknesses were considered sufficiently major to reject the use of PIM. The report recommended that capital stock estimates be based on a direct observation method similar to that used by the Netherlands Statistical Office, and that PIM be used only as a supplementary method to provide data for the periods between direct observation benchmarks.

9. IES cite a number of limitations as grounds for rejecting PIM as the foundation for capital stock measurement. These criticisms tend to fall into three categories.

Assumptions on average asset lives and their distribution.

10. IES note:

- The method relies upon accurate assessment of disinvestment. Direct observation of economic depreciation is rarely available for all sectors and all periods.

- There may be extreme variation in fact between average life of capital stock of the same vintage between different firms and different sectors. Investigations in the Netherlands show that the lifetime of the same capital goods may vary between 17 and 3 years depending on the industry.

- No account is taken of the intensity of use over the lifetime of the asset. Thus, whilst it is usual for transport firms to measure the age of trucks by means of hours run this measure is not used when incorporating those trucks into the capital stock data.

- No account is taken of the fact that usage of capital stock may change over time and that much disinvestment occurs through this cause.

- The age/effectiveness profile may not be fixed for a given vintage of a capital good throughout its presumed lifetime. Instead it is likely to vary with the business cycle and with the return to capital.

11. The issue of disinvestment or retirement of assets from the capital stock centres on the contentious issue of the productive life time of a given asset. Estimates of mean asset lives play a critical role in PIM calculations. Surprisingly very little hard data exists on actual asset lives. Present OECD estimates are derived from prevailing tax lives, company accounts, 'expert' advice, other countries estimates and an eclectic mix of often dated survey data, resulting in service life estimates which vary widely. *Methods Used By OECD Countries To Measure Stocks Of Fixed Capital*, OECD, 1992. For example, average service lives of machinery and equipment (excluding vehicles) in the Food & Beverage industry range from 11 years in Japan to 26 years in the UK. Ibid. p.13. This level of disparity is typical of the estimates being used in this area. This variation is reflected in any productivity measures subsequently derived.

12. The inconclusive attempts made to provide accurate estimates of asset lives may be implicit recognition of the difficulty of quantifying such lives in a modern economy. It is feasible the life of a particular type of asset will vary widely between industries and possibly between firms in a given industry . This is a major concern, given, as the Australian Bureau of Statistics (ABS) argue, that the most critical assumptions underlying PIM are the estimation of mean asset lives and to a lesser extent the assumed distribution of lives about this mean Walters R. & Dipplesman R.,*Estimates of Depreciation and Capital Stock, Australia*, Occasional Paper 1985/3, Australian Bureau of Statistics..

13. In addition the ABS have concluded that the pattern of disinvestment has not been constant over time and have built into their system an arbitrary reduction in the asset lives of equipment of 5% per decade. This assumption of a broad based reduction in asset lives is not universally adopted. Given the critical nature of these estimates for the production of capital stock figures, does the lack of accurate mean asset life data place the usefulness of

PIM series in doubt?

14. In New Zealand, there may be an opportunity to improve on the OECD based estimates of mean asset lives and retirement patterns that are currently used in the Philpott series. The IRD depreciation survey referred to above was conducted by SNZ and captured economy wide data on the actual service lives of a wide range of specific assets of differing vintages. By grouping these into a more manageable number of asset types and industrially classifying respondents, the data should lead to improved estimates of average service lives.

15. Improved service life estimates are, however, only part of the solution. PIM cannot readily incorporate the impact of unforeseen obsolescence. The calculation of mean asset lives cannot include allowances for random events such as natural disasters, oil shocks etc. It is unclear how unforeseen obsolescence is currently handled in OECD countries. It may be possible to incorporate ad hoc adjustments to final capital stock estimates where a particular event has clearly impacted on a given asset group. Whether such adjustments are feasible may depend on the data available concerning a specific catastrophe or occurrence.

Nominal capital expenditure data.

16. IES note:

The time series used should be long and without disturbance. This means that:

"...the book value one requires should be taken at a point in time before which there has been a run of years, at least equal to the life of the longest lived asset included, in which there has been absolute stability in the price of assets, and in which accumulation of them has proceeded at a steady or uniform rate of growth so that the stock of assets poses in some sense of the word, a balanced age structure." (*Real Net Capital Stock By SNA Production Groups*, B.Philpott, RPEP Paper 270, p.3).

17. The capital stock figures produced by PIM are heavily dependent on the quality of the investment data which underlie them. Given that the PIM approach requires investment series of a length at least equal to the life of a particular asset, data problems can be severe. It is clear that in addition to the problems associated with choosing the parameters of a PIM model the length of investment series required, particularly for estimates of *Non-dwelling Construction* and *Dwellings*, will inevitably result in problems of data availability. This problem is particularly acute in NZ where official estimates of gross fixed capital expenditure are not available prior to 1972. These problems will be compounded by attempts to produce retrospective capital series. i.e. the earlier the start point the more severe the data problems.

18. The age/length of the series required will be a function of the starting point chosen, the mean asset life and the distribution of retirements. Examples of this variation are provided in the following table:

Mean Asset Life	Retirement Pattern (1)	Length of gross fixed capital expenditure series
15 years	Simultaneous exit	15 years
	Delayed Linear - retirements within ± 20% of MAL	17 years
	Linear	30 Years
30 years	SE	30 years
	DL	35 years
	L	60 years
1. The retirement patterns used are just a few of a large number of possible forms used by different organisations		

19. Philpott overcame this problem by using a starting point technique which hypothesised that a constant relationship between book values, replacement value and market value existed. Therefore one could revalue book values to provide an approximate starting point for an on-going PIM series. The appropriate ratios for revaluation are supplied by a modelling process. How valid is this?

20. While the ABS have the advantage of longer capital expenditure series from 1948 onwards they too have experienced difficulties in obtaining sufficient historical data in a number of areas. When necessary they have resorted to regressing the series in line with a proxy indicator variable. While the technique relies upon a number of subjective choices, this is partially justified by the low weight these figures exercise in the final series.

21. To satisfy user demands, the capital stock series need to be compiled at a detailed asset level (which is also needed for more accurate deflation) and analysed by industry. Whether the limited availability of capital expenditure data in New Zealand - across time, industry and asset type - is sufficient to reduce the accuracy of the resulting PIM stock measures has yet to be determined.

22. In the case of Philpott's 1950 to 1972 estimates, data limitations restricted the asset split to two groups: building & construction, and plant & machinery. Investment

data for the series was drawn from numerous studies of investment in particular industries by various authors. This data was then realigned with SNZ inter-industry studies. It is clear the assumptions and decisions made in relation to these series were sometimes dictated by data availability rather than theoretical correctness or accuracy.

Capital asset price indexes.

23. The adequacy of the price indexes used can have a considerable influence on the accuracy of the final series, particularly in relation to the measurement of quality change over long time periods. At an industry or institutional sector level the question of incorporating second hand asset transactions can be important.

24. It is arguable whether asset-type price indexes are appropriate deflators across all industries, i.e. just as the capital expenditure series need to be compiled at a detailed industry * asset level, so industry specific asset indexes may be needed. The extent of this potential problem has not been examined in New Zealand.

Accuracy of PIM measures.

25. IES note that an error introduced into the analysis is not removed until the capital goods concerned disappear from the calculations many years in the future. There is no self checking mechanism in the method.

26. The Netherlands Statistical Office, the CBS, is the only organisation which operates a system similar to that recommended by IES The United Kingdom Office for National Statistics is also investigating this approach. Refer Paul West, *The Problems of the Perpetual Inventory Method, and the UK's Evaluation of Direct Collection as an Alternative Method,* paper presented at the 1996 IARIW conference, Norway. They recently produced a paper comparing the results obtained by PIM and direct observation Frenken J. *How to Measure Tangible Capital Stock,* CBS August 1992. Despite the PIM estimates being benchmarked by direct observation (an advantage a pure PIM system would not have) the CBS found the systems estimates were poor, even over short time periods. They found the difficulties in obtaining accurate data on disinvestment and mean asset lives badly influences the PIM results.

"In general PIM isn't doing well in the Dutch situation. DOC (direct observation of capital) is needed as a benchmark once in a while to keep the right course. It is remarkable and frightening that in a few years a PIM filled with unsuitable parameters causes strong deviation from reality." (P16 Frenken)

27. While direct observation does not suffer from these shortcomings they have found it to be expensive and time consuming, placing a heavy burden on both statisticians and industry. An additional drawback in a NZ context is the inability of a direct observation method to provide historical series. Without the use of PIM it would not be possible to produce retrospective series on capital stock, current cost depreciation or rates of return on capital. In addition attempts to produce historic capital stock series will be constrained by investment data limitations prior to 1972.

28. IES also argue that the PIM approach results in productivity measures which may

be determined more by historic prices, wages and technology than by movements in technical efficiency which it is intended they capture. In theory capital productivity is the ratio of output in a given period to a known quantity of capital services used in production during this period. As the quantity of capital services is not known the value of the capital stock used during the period acts as a proxy. PIM arrives at this stock figure by summing investment over a large number of previous periods. As a consequence the desired snapshot of one period's productive input and output may be distorted by the introduction of a component which has been summed over many earlier periods. In this way the influence of the factors which have determined capital accumulation over this period (i.e. historic prices, wages, technology etc) may be introduced into the capital productivity measure produced.

Conclusion

29. Although the IES consultant has recommended that capital stock series in New Zealand be based on direct observation coupled with supplementary PIM estimates for non-benchmark years, without a substantial increase in resources this approach is unlikely to be adopted. It is believed the only realistic method for producing such data in the short term is provided by the perpetual inventory method, especially as historical series are required.

30. The adoption of this approach in NZ will be more difficult than that experienced in other countries due to the limited time series of capital expenditure and asset prices available. Potentially, New Zealand has a good source of data on asset lives although this source has yet to be proven. It will not, however, provide the answers to the numerous issues relating to asset lives and mortality functions noted above.

31. Preliminary development work done to date has highlighted the sensitivity of the final capital stock series to assumptions on average asset lives, mortality functions and 'errors' in the nominal investment series. Indeed, the size of these differences reinforces the consultants view. When combined with the additional problems that will arise through known deficiencies in deflators and varying utilisation levels which cannot be adequately factored in, then considerable doubt is cast on the value of PIM based stock measures for one of their main uses, viz. productivity analysis.

National Accounts Division February 1997