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Australia's methodology for compiling estimates of Capital Stock and Consumption of Fixed Capital

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SECTION 1. INTRODUCTION

1. This paper provides an overview of the methodology used by the Australian Bureau of Statistics (ABS) to compile annual and quarterly estimates of capital stock and consumption of fixed capital.

2. Annual estimates are compiled through a Perpetual Inventory Method (PIM) maintained and updated within the ABS. Quarterly estimates are constructed by interpolating between the annual estimates and extrapolating from the latest annual estimates to produce estimates for the latest quarters. Detailed estimates are published annually in Australian National Accounts: Capital Stock (5221.0). Summary estimates are included in Australian National Accounts: National Income, Expenditure, and Product (5204.0).

3. Section 2 of this paper outlines the approach currently employed by the ABS in the estimation of capital stock, focusing primarily on the Perpetual-Inventory Method. The assumptions made are described, including those concerning length of asset lives, their distribution, and the rate of depreciation. Section 3 discusses major problems with existing methods. Section 4 broadly details the ABS work-program designed to improve both the accuracy and consistency of the capital stock estimates.

SECTION 2. METHODOLOGY

Valuation and classification of capital stock

Valuation

4. Capital stock and consumption of fixed capital are presented in the Australian national accounts in constant price and current replacement cost terms only. In constant price valuation, assets are valued at a base year price (currently 1989-90) regardless of their actual prices in the year of acquisition. Current replacement cost valuation expresses all assets in the capital stock at the price that would have been paid for them if they were purchased in the reference year.

Classification of asset types, institutional sector and industry

5. Current and constant price estimates of gross and net capital stock are compiled by institutional sector by industry. The level of sectoral and industry disaggregation is shown below.

Institutional Sectors

Estimates of capital stock, including real estate transfer expenses, are available for the following broad sectors:

- Private enterprises
- Public authorities

A more detailed sectoral split is available for estimates of capital stock, excluding real estate transfer expenses, as follows:

- Private enterprises
  - Private corporate trading enterprises
  - Private financial enterprises
  - Unincorporated enterprises and dwellings owned by persons
- Public authorities
  - Public trading enterprises
  - Public financial enterprises
  - General government

Asset types

For each institutional sector, estimates are compiled for the following broad asset types:

- Dwellings;
- Non-dwelling construction;
- Equipment; and
- Real estate transfer expenses.

Industries

Estimates for Non-dwelling construction and Equipment are also available for the following industries which broadly correspond to the top level of the Australian and New Zealand Standard Industry Classification (ANZSIC) :

Private enterprises:

- Agriculture, forestry, & fishing
- Mining
- Manufacturing
- Electricity, gas & water
- Construction
- Wholesale trade
- Retail trade
- Accommodation, cafes and restaurants
- Transport, storage & communication
- Finance and insurance
- Property and business services
- Education
- Health and community services
- Cultural and recreational services
- Personal and other services

Public trading enterprises:

- Electricity, gas and water
- Transport, storage & communication

Gross and net rates of return

Estimates of gross and net rates of return are published by:

- Private corporate trading enterprises
- Public trading enterprises

The Perpetual-Inventory Method (PIM)

Gross and net capital stock

6. The main steps in the PIM employed by the ABS are outlined in Appendix A. Annual estimates of gross capital stock are derived by accumulating past flows of gross fixed capital expenditure (GFCE) and deducting the estimated value of retirements from the stock. Annual estimates of consumption of fixed capital (CFC), and hence net capital stock, are derived using a straight line depreciation function based on the assumed expected economic lives of the assets and how these asset lives are distributed. Quarterly estimates of CFC are not produced by the PIM but are derived from the annual estimates using linear interpolation and extrapolation.

7. GFCE and the gross and net capital stock levels at the beginning of the period are deflated to constant prices (base=1989-90) before retirement and depreciation functions are applied in the PIM. Estimates are produced by ANZSIC division (ANZSIC is the Australian and New Zealand Standard Industry Classification and, division is the highest level of the classification, refer to previous page for details) at both constant prices and current prices.

8. *Average age* of the gross capital stock at the end of each year is produced as a by product of the model. Average age is the age at 30 June of past years' GFCE weighted by their proportions of the gross stock. These calculations assume an average midyear purchase.

Historical estimates

9. Aggregates of the estimates of capital expenditure equal to the longest possible life of the capital good in each component form the basis of the existing estimates of gross capital stock. The first year for which estimates of capital stock and consumption of fixed capital have been published is 1966-67. At that time assets purchased in 1948-49 would have attained an age of only 18 years, whereas the great majority of structures and a minority of equipment types are assumed to survive longer than 18 years. Therefore, in order to estimate capital stock and consumption of fixed capital from 1966-67, estimates of GFCE are required for years prior to 1948-49. The length of the detailed GFCE series required depends on the particular mean asset life and asset life distribution which applies to that series.

10. Estimates of gross fixed capital expenditure for years prior to 1948-49 are generally less accurate than those since 1948-49. However, because of the retirement of older assets and the rapid growth of the Australian economy since World War II, the early data have relatively little impact on the present estimates. Sources for these estimates include both ABS and non-ABS data.

Obtaining GFCE for the current period

11. Gross fixed capital expenditure (GFCE) estimates by industry by institutional sector and by asset type (as listed above) are required as input into the PIM. GFCE is published from 1948-49 onwards and the data sources are those underlying the national income, expenditure and product accounts. GFCE includes building and equipment purchases, both new and second-hand, and improvements and alterations to durable assets which significantly extend their productive life. Excluded are military goods purchased by government (because their future productive capacity is uncertain); and net additions to livestock (because of volatility due to drought, fire, flood and world market conditions).

12. Quarterly GFCE estimates for private sector *dwellings* and *non-dwelling construction*

are obtained primarily from the ABS quarterly Building Activity Survey and Engineering Construction Survey. These are aggregated to compile annual estimates and the ABS quarterly Private New Capital Expenditure Survey is used as an indicator for industry and sectoral information. Annual GFCE *equipment* estimates for the private sector are sourced from taxation data and converted to quarterly data using mainly the quarterly Private New Capital Expenditure Survey as an indicator. The quarterly survey provides information in respect of some, but not all, industries. Adjustments are therefore made in order to account for the industries which are out of scope of the source series and to adjust for the acquisition and disposal of used assets. Annual GFCE *real estate transfer expenses* are also primarily obtained from taxation data and a variety of sources are combined with that source to compile the quarterly estimates. Annual GFCE data for *public enterprises* is sourced from public finance estimates mainly from public enterprise Annual Reports and Auditors'-General reports. Quarterly estimates are based on a quarterly collection covering all significant public enterprises and a sample survey of local government authorities. Finally, annual GFCE estimates for *general government* are mainly sourced from various budget papers and, in the case of quarterly data, government ledgers.

13. There are a number of problems with the generation of detailed capital expenditure estimates which affect the reliability of estimates produced by the PIM. In particular, sector and industry estimates of private gross fixed capital expenditure on equipment are not as detailed as ideally required and there is a lack of detailed data on second hand transactions in non dwelling construction assets. These limitations are discussed in Section 3.

Asset lives

14. The mean asset lives are the most important of the assumptions used in the PIM. Together with asset life distributions, they determine when assets are retired from the gross capital stock, the rate of depreciation charged and hence the net stock. Five main data sources are used to derive estimates of mean asset lives: implicit tax lives; weighted prescribed tax lives; asset lives used by businesses to calculate depreciation for their own purposes; asset lives derived from data about the stock of various types of assets; and asset lives used in the perpetual inventory models of national statistical offices in other OECD countries. The mean asset lives used in the PIM are shown in Appendix B.

15. Rather than assuming that all assets are retired at the mean asset life for a particular category of assets, the PIM estimates allow for a probability distribution of retirements about the mean life, referred to as an asset life distribution.

16. Available data on purchases of assets are aggregative, consisting of many different individual assets, each with its own particular asset life. Even for individual assets, variations in asset lives will be observed because of differences in the rate of usage, repair and maintenance policy, etc. Because of the lack of recent empirical evidence, asset life distribution curves developed by Winfrey in 1938 are used. The Winfrey S3 is a bell-shaped symmetric curve, with approximately three quarters of assets retiring within thirty per cent of the mean asset life. It is empirically based, related to variations in lives for individual assets, and is consistent with the general presumption that asset lives for an individual asset will follow approximately a normal distribution. Exceptions to the use of Winfrey S3 are made for alterations and additions and real estate transfer expenses. In both cases the flat symmetrical Winfrey SO is used, reflecting the belief that lives for these assets are likely to be widely dispersed rather than being clustered about the mean.

Depreciation

17. The ABS employs the concept of economic depreciation (rather than efficiency depreciation, commercial accounting depreciation, or taxation depreciation) as this is the concept consistent with the definition of consumption of fixed capital in the System of National Accounts (SNA). This concept refers to that part of gross product which is required to replace fixed capital used up in the production process during an accounting period.

18. The ABS uses a conventional straight line depreciation function (rather than a geometric decay or other function) in the Australian estimates. This accords with the recommendations in the SNA and is the depreciation function adopted in most overseas PIM estimates. It is also regarded as a reasonable compromise solution, and has a practical advantage in view of its ease of computation.

Use of price indexes in PIM

19. Price indexes are used to convert all expenditure and costs of capital goods that occur in different periods to a similar monetary unit so that they can be aggregated and to ascertain a time independent level of real purchasing power forgone. In PIM, this is achieved by deflating current price gross and net capital stock at the beginning of the period, and current period GFCE to constant prices before determining retirements and depreciation.

20. The price indexes used in PIM are drawn from the same sources as those used in the Australian National Accounts (ANA) system. ABS price indexes are only available back to 1948-49. For equipment they comprise ABS price indexes of Australian manufactured goods, imports, and several price indexes compiled by overseas agencies - most notably the US Bureau of Economic Analysis' (BEA) computer equipment price index. For construction a variety of price indexes are used: output price indexes for houses; pseudo output price indexes for non-house dwellings and non-dwelling building; and input price indexes for engineering construction. Because the available price indexes relate to a number of different base periods it is necessary to splice the price indexes with different base periods on the basis of relationships in overlapping periods. Asset based price indexes, such as those based on the sale of capital items are conceptually preferred. However, due to data limitations, the price indexes employed are sourced from a combination of inputs based price indexes (predominantly from the producer price indexes) and asset price indexes.

21. In general, the elemental price indexes for equipment are Laspeyres indexes (a notable exception is the BEA's computer equipment price index, which is a chain Fisher). The elemental price indexes are formed into a Paasche index using weights derived from a supply-side model. The price indexes for houses, non-house dwellings, alterations and additions to dwellings, non-dwelling building and engineering construction are all essentially Laspeyres indexes, although their weights do vary according to levels of activity in each state and territory.

22. In selecting a mid point of prices to represent a whole period price movement for GFCE, depreciation, and retirements, the PIM model treats prices as though they change in a linear fashion within that period.

23. The limitations of the existing formula, in particular that it is subject to substitution bias over time is generally understood. This limitation is addressed by the future ABS work program to introduce chain linked indices which are generally not subject to such biases.

Reflation of capital stock to current prices

24. Estimates of gross capital stock, net capital stock and consumption of fixed capital at current replacement cost are obtained by reflating the constant price estimates to current price values. The price indexes used to reflate the constant price estimates are the same as those initially employed to deflate GFCE, except that they are adjusted to an end year basis by averaging the price indexes for year t and year t+1. The resulting series at current and constant prices are aggregated to the level published.

SECTION 3. WEAKNESSES OF THE PIM

25. The weaknesses relating to the PIM method are twofold. Firstly, there are deficiencies in the data sources used in PIM and, secondly, there are weaknesses in the assumptions.

26. On the data input side there are a number of problems with the generation of detailed capital expenditure estimates which affect the reliability of estimates produced by PIM. They can be summarised as follows:

a. **Industry estimates of GFCE.** The estimates of GFCE by industry are less accurate than the totals. In particular, it can be difficult to attribute the capital expenditure to the industry which will be using the asset rather than the industry that actually purchases/owns it. This issue is of importance in the case of assets which are acquired by the end user under various leasing arrangements. Although Australian Accounting standards, and consequentially GFCE data collected by and provided to the ABS, require that assets acquired under finance leases be reported as capital expenditure by the end user there is currently no viable method of allocating assets used under operating lease arrangements to the industry of use rather than industry of ownership.

b. **Transactions in used assets.** There is a lack of information regarding transactions in used assets. This causes a potentially distorting effect since the prices of second-hand fixed assets are excluded from the construction of price indices used in the PIM model. More importantly, data for sales of used assets within the private sector are not available -- they are available only for sales of second-hand assets between private and public sectors.

c. **Accuracy of historical estimates.** Recently the ABS reviewed and upgraded the standard industry classification used for the compilation and presentation of statistics by industry. The reclassification of capital stock estimates on an ANZSIC basis has required the compilation of current and constant price estimates of gross fixed capital expenditure on an ANZSIC basis back over many years. For some industries where the changes to the classification are significant, notably service industries, it has proved difficult to adequately backcast the capital stock estimates to accord with the updated classification.

d. **Inter-sectoral movements.** Ideally, the capital stock estimates should accurately reflect inter-sectoral movements of enterprises. However, in the Australian experience, it has proven difficult to implement capital stock adjustments satisfactorily, especially with respect to units moving from the public to the private sector as a result of the sale of public assets (for example, the sale of QANTAS and Commonwealth Bank). The main difficulty is that the value of the assets recorded in the transaction will usually not be at replacement cost which is the valuation required for capital stock estimates. Further, assets transferred which have already been in service for some time are treated as being new to the acquiring sector. The asset life attributed to the asset is the same as if it were a new asset. This means that the asset will remain in the capital stock estimates for a period exceeding its productive life. Given these problems with using sale prices, the ABS is, where possible, compiling separate capital stock estimates for each business that has been privatised. This has been possible for all the significant public trading enterprises, but none of the public financial enterprises.

27. On the assumption side, major weaknesses relate to the mean asset life and the distribution of asset lives. These concerns can be summarised as follows:

a. **Mean asset lives are not based on recent empirical studies.** In recognizing that the general trend in asset life assumptions has been decreasing over time, the ABS reduces the mean asset life of equipment by 5 per cent per decade. However, recent anecdotal evidence based on economic relationships suggests that mean asset lives are still over-stated.

b. **The asset retirement functions are also questionable.** The asset retirement functions are based on outdated empirical studies - they were done back in the 1930s and were heavily influenced by railway infrastructure. Therefore the assumptions may be of less relevance today.

c. **The depreciation assumptions need to be reconsidered.** Because the using up of fixed capital is not an observable phenomenon, it has given rise to considerable disagreement in the literature about the way in which capital consumption should be measured. In addition, empirical evidence to date on the patterns of efficiency and economic depreciation has not provided firm conclusions as to the appropriate choice of function. However, the choice of using a straight line depreciation function in the PIM model needs to be reconsidered in conjunction with the choice of asset life assumptions. For example, a straight line economic depreciation with a short asset life may be quite similar to geometric decay with a long asset life.

SECTION 4. MAJOR CHANGES PLANNED BY THE ABS

28. As specified in the previous section, the annual estimates of capital stock have a number of significant deficiencies, particularly in respect of assumptions about asset lives. These shortcomings have been recognised and the ABS is currently considering options to address these issues with the aim of redeveloping and extending the capital stock estimation system over the next few years. The project has the following objectives:

a. **To develop more accurate capital stock estimates.** There is an urgent need to review asset life estimates and retirement and depreciation functions as embedded in the current PIM and to propose alternative assumptions on the basis of information collected either directly or indirectly:

- The information obtained <u>indirectly</u> may include drawing on data from the Australian Taxation Office, overseas statistical agencies and other sources (including major asset owners, electricity generation and distribution enterprises, road, port and airport authorities, major manufacturing and mining enterprises and real estate owners).

- In the medium-term, the ABS is also planning to undertake a feasibility study to determine the cost-effectiveness of <u>directly</u> surveying businesses to obtain data that would lead to a better capital stock estimates.

b. **To develop more consistent capital stock estimates.** The redevelopment of the capital stock system to be more consistent requires:

- **Implementation of the 1993 System of National Accounts (SNA93).** This requires the extension of asset types, dissection by asset type, the incorporation of chain volume indexes to replace the existing fixed base year constant price estimates and updating the sectoral and industry dissections used.

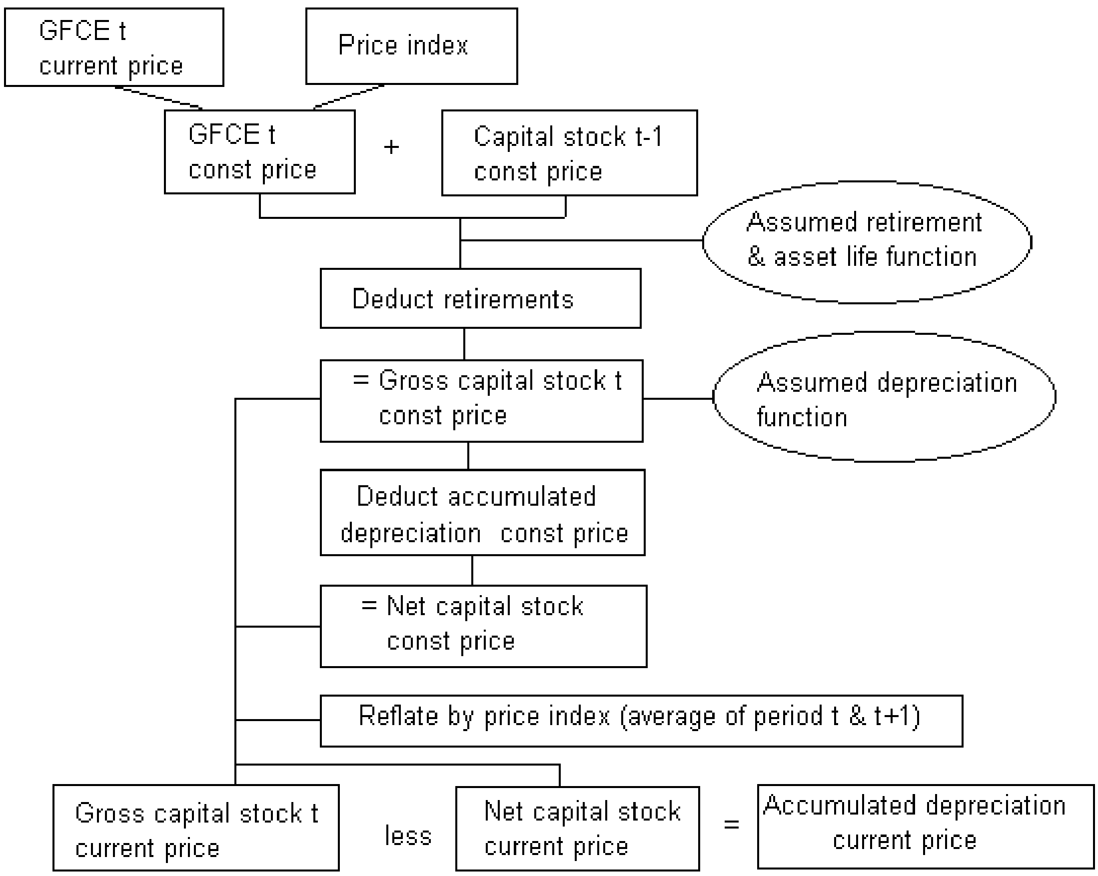
- **Implementation of an Input-Output (I-O) based national accounts system.** Aligning capital stock estimates with the I-O based national accounts requires the development of a quarterly supply-use model for capital equipment. The model will serve two purposes. First, it will be used to derive capital expenditure on equipment by asset type for past periods, which will be used in the capital stock system. This will enable asset lives to be allocated to each of these asset types (of which computing equipment is one) independently, and so largely overcome a major weakness in the present system. Second, it will be used to monitor the equipment estimates from the quarterly Survey of New Capital Expenditure.

Appendix A: PIM model approach

Main steps in the PIM employed by ABS

1. From the previous PIM iteration the level of Capital Stock by asset type by institutional sector by industry is available at constant prices (1989-90 currently)
2. Determine current price Gross Fixed Capital Expenditure [GFCE] for the period and deflate GFCE to constant prices
3. Add constant price GFCE to constant price estimates of capital stock
4. Determine all retirements from the capital stock for the period - using retirement and mean asset life assumptions.
5. Calculate end of period <u>Gross capital stock</u> (constant price) = beginning of period gross capital stock + GFCE - retirements
6. Determine depreciation of the capital stock for the period - using assumed depreciation patterns
7. Calculate <u>Net capital stock</u> (constant price) = Gross capital stock - accumulated depreciation
8. Reflate both the gross and net capital stock estimates by available price indexes to current prices - Note this allows the computation of depreciation at current prices

PIM Model Structure



Appendix B: Mean Asset lives (Years)

Dwellings: -	
Private brick houses	90
Private timber, fibro and other houses	60
Private non-house dwellings (units, flats etc.)	60
Private alterations and additions	40
Public	60

Real Estate Transfer Expenses: -	
Dwellings	15
Non-dwelling construction	25

Non-Dwelling Construction and Equipment

	Non-Dwelling Construction				
	New Bldg	Constructn (other than bldg)	Alterat & Additns	Weighted Average	Equipment
Agriculture, forestry, fishing & hunting	50	40	25	43	13
Mining	65	25	25	31	16
Manufacturing	45	45	20	39	19
Electricity, gas & water -					
Private	50	60	25	56	22
Public trading enterprises -					
Electricity and gas	50,30	30-60	na	38	25
Water, sewerage & drainage	50	50-100	na	72	22
Construction	50	na	25	45	13
Wholesale and retail trade	60	na	30	51	16
Transport, storage & communication -					
Private	45	na	25	41	14
Public trading enterprises -					
Urban transit	75, 40	55	25	52	22
Rail transport	75, 40	80	25	67	30
Sea transport	60	45-50	25	48	19
Air transport	50	na	14	32	18
Other transport & storage	55	35	na	50	17
Communication	65	various	various	50	19
Finance	65	na	30	58	13
Community services	65	na	30	51	15
Recreation, personal & other services -					
Private	60	na	30	51	15
Public trading enterprises	50	na	10	42	13
General government -	--	--	--	--	15
Roads	na	10, 75	10, 35	34	--
Other	65	na	30	54	--

Note: Asset life assumptions above are based on the old industry basis and still need to be re-classified to the new (ANZSIC) industry basis.