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SEMINAR ON MEASURING CAPITAL – BEYOND THE TRADITIONAL MEASURES
SESSION II

An Integrated System of Capital Flow and Stock Statistics[1]

Submitted by the Australian Bureau of Statistics

INTRODUCTION

1. Statistics on (physical) capital are an important part of the national accounts. Traditionally, the wealth aspects of capital have been the focus of national accounts compilation efforts. These wealth aspects relate to the initial accumulation of capital through investment and the 'running down' of these investments over time by way of consumption of fixed capital (depreciation). Flows associated with the accumulation of new capital and the depreciation of existing capital are recorded in the national accounts capital account. The (written down) values of capital assets are recorded in the balance sheets. The change in the value of the balance sheets over time can be explained by the transactions recorded in the capital account and, to the extent there are price changes or other changes in volume affecting the capital assets, by the flows recorded in the other changes in assets account.

2. However, there is another dimension of capital that has attracted increasing attention by national accountants in recent years, and that is the role of capital in productivity analysis.

[1] This paper has been prepared at the invitation of the secretariat.

Broadly defined, productivity represents the difference in growth rates between outputs and inputs and, as such, is a source of economic growth. Accordingly, it is often the focus of government economic policy because, all other things equal, a higher rate of productivity allows an economy to grow more rapidly for a given set of inputs. In Australia, for example, much of the government's economic policy is built around the 3P's framework – population, participation and productivity -- which taken collectively are seen as the fundamental drivers of economic growth. Capital, of course, is one of the traditional economic inputs along with labour, so any comprehensive analysis of productivity must include an analysis of the role that capital plays in productivity.

3. The wealth and productive dimensions of capital are not independent and in fact, as will be demonstrated shortly, the latter drives the former. Because of the dependencies that exist between the two measures, the estimates for both dimensions should be compiled within a single, coherent framework. This is the approach taken in Australia. The Australian Bureau of Statistics (ABS) has developed a perpetual inventory model that produces estimates for both the wealth and productive dimensions of capital in an integrated fashion. The benefit of this approach is that the wealth measures contained in the national accounts are fully consistent with measures used for productivity analysis. This is important because the end target of productivity analysis – economic growth – is one of the fundamental measures provided in a set of national accounts.

I. A SIMPLE CAPITAL MODEL

4. Suppose that there is an asset that will be used in production for two years. In year 1, the value of that asset's contribution to production is estimated to be 50. In year 2, the asset is estimated to also contribute 50 to production. We also suppose that the interest rate is 10% and that there are no price changes.

5. At the beginning of year 1, the value of the asset can be estimated to be 95, which is equal to its first year's contribution to production of 50 plus the second year's contribution of 50 discounted by 10%, or 45. In properly functioning markets, the new value of the asset will be 95. Users of the asset will be willing to pay up to 95, but no more, to acquire the asset. As well as representing the amount that is needed to acquire the asset, the 95 represents the initial wealth value of the asset.

6. At the beginning of year 2, the asset is worth 50, which is the value of the asset's contribution to production in year 2. Thus, in year 1, the value of the asset has fallen by 45 (95 – 50). It is this amount which is shown as consumption of fixed capital in the national accounts. At the end of year 2, the asset is worthless and the consumption of fixed capital during year 2 is therefore 50.[2]

7. We now have a pattern for the change in the value of the asset over time – 95, 50 and 0. This pattern is known as the *age-price* profile. The values generated by the age-price profile are the values of *net capital stock*, which is the essential measure of capital from a wealth

[2] It may be interesting to note at this point that, although the asset's contribution to production in both years is 50, there are different amounts of consumption of fixed capital in the first and second years.

perspective.

8. Turning now to look at the asset from a productivity perspective, we can see that the asset contributes equally to production in both years. This means that the asset is equally efficient in both years – there has been no decline in efficiency between years 1 and 2. A light bulb is a good example of this type of asset. The two estimates of the asset's value in production – 50 and 50 – represent the asset's *age-efficiency* profile. Using the age-efficiency pattern an alternative measure of capital stock – *productive capital stock* – can be derived. This measure is calculated by expressing each year's age-efficiency value as a proportion of the new value of the asset and it is a measure of the productive capability of an economy's capital stock.

9. There are a few important implications that arise from the foregoing. First, it is the age-efficiency profile that determines the age price-profile, and not vice versa. In other words, the amount of consumption of fixed capital on an asset is directly related to the asset's productive capacity over time. This can be demonstrated by changing the assumption about the value of the asset's contribution to production in year 2 from 50 to 30. In this case, the age-price profile of the asset changes to 77 (new), 30 (at the beginning of year 2) and 0 (at the end of year 2). The resultant estimates for consumption of fixed capital are now 47 in year 1(compared to 45 in the earlier example) and 30 in year 2 (compared with 50 in the previous example). The change in productive capacity has caused the pattern of depreciation to be significantly altered, with more consumption of fixed capital now being recorded in the first period and less in the second.

10. Second, the values of the asset's contribution to production in each year represent the input of capital into the production processes. It is precisely these inputs (generally when measured in volume terms) that are of interest to productivity studies. In productivity analysis, these capital inputs are known as *capital services*. When capital is provided under rental arrangements, in properly functioning markets the value of the rental is equal to the capital services provided by the asset (ignoring other costs for simplicity).

11. Third, the value of the capital services in any given period can be seen to be equal to the sum of consumption of fixed capital plus the 'unwinding of the discount'. In our original example, the capital services in year 1 of 50 is equal to consumption of fixed capital of 45 in year 1 plus 10% of the value of the capital at the end of year 1, or 5.[3] This value of 5 is also sometimes known as the *return to capital*. It is important economically because an owner will only invest in a capital asset if its return from production covers both the loss in value of an asset via consumption of fixed capital and the opportunity cost of the owner investing his funds in the asset compared to some alternative investment. One of the features of SNA Rev 1 will be a discussion of the relationship between capital services and 'traditional' national accounts measures of capital, including suggestions for supplementary tables designed to highlight the capital services/return to capital dimensions of capital.

[3] Strictly speaking, the discount should be applied to the average value of the capital during the period, not at the end of the period. But the identity that capital services equals the sum of consumption of fixed capital plus the unwinding of the discount still holds, because in 'proper' capital stock models the wealth values are calculated by applying the discount continuously and not just at the end of the period as in our simple examples.

12. Clearly, the examples above are simplistic. But the basic points illustrated relate to all kinds of capital assets with many and varied assets lives and productive capacities. And it is possible to mathematically express these relationships. It is these mathematical expressions that are at the heart of the integrated capital stock system in Australia.

13. To summarise, there are three relevant capital flows:

(a) Accumulation (or initial investment);
(b) Consumption of fixed capital (or depreciation);
(c) Capital services.

14. And three relevant capital stock measures:

(a) Gross capital stock, which represents the initial, new, value of assets;
(b) Net capital stock, which represent the 'written down' value of capital due to consumption of fixed capital;
(c) Productive capital stock, which represents the 'written down' value of the asset in accordance with its change in efficiency.

15. The various measures of capital, and the relationships between them, are set out in a more substantial manner in the OECD's Manual on *Measuring Capital* (2001).

II. PERPETUAL INVENTORY MODELS

16. As mentioned above, Australia uses a *perpetual inventory model (PIM)* to compile its capital stock estimates.

17. The PIM involves the compilation of a 'rolling' inventory of capital stocks; in any particular period investment in capital assets is added to stocks, and retired assets are deducted. To apply the PIM, the following are generally required:

(a) the average length of asset lives, i.e. average of the length of time they are used in production;

(b) the extent to which assets are retired before, on or after the average asset life for that asset - the retirement distribution. Alternatively, retirements can be expressed as a survival function;

(c) the age-price function of assets (used to derive net capital stock estimates and estimates of consumption of fixed capital);

(d) the age-efficiency function of assets (used to derive productive capital stock estimates and estimates of capital services);

(e) gross fixed capital formation (GFCF) for the period for which the capital stock estimate is required and for periods prior to that period equal to the maximum life of the asset;

(f) price indexes for the entire time span of GFCF.

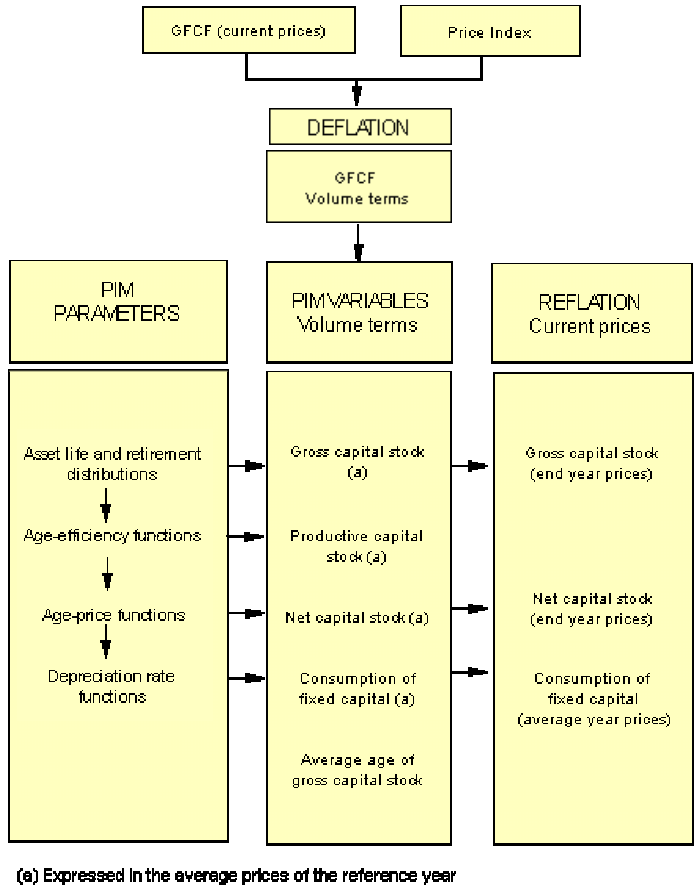
18. The alternative to using a PIM to derive capital stock estimates is to use direct measurement. However, there are significant drawbacks with this approach, mainly associated with the paucity of data that are available. For estimates of net capital stocks, there are simply insufficient observations of the second-hand value of assets, given that only a small proportion of assets are actively traded in second-hand markets. While the accounts of businesses typically contain – in the balance sheets – estimates of the 'written down' values of assets, the depreciation estimates underlying these values are typically inconsistent with the calculation of consumption for fixed capital in the national accounts. This is because accountants' measures of depreciation are often based on simple 'rules', such as straight-line depreciation. Studies have shown that these methods are often a poor representation of the actual consumption of fixed capital. Another common problem is that book estimates of depreciation, and consequently asset values, are often based on historical cost, whereas the national accounts requires estimates based on current values. Thirdly, the asset lives chosen for estimating depreciation may be artificially shortened, for tax purposes for example.

19. Turning to the productive dimension of capital, the situation in terms of availability of direct data is possibly even worse. Few businesses have, as a matter of course, comprehensive estimates of productive capital stock or of the capital services generated by their assets. While it is possible to observe the values of capital services from the rentals of assets, for most types of assets the market for operational leasing is typically very small relative to the total stock of the asset or even non-existent.

20. However, the PIM also has drawbacks as an approach. There are two main drawbacks. First, very long time series are needed for the two key inputs – GFCF estimates and the associate price indexes. In fact, input information is generally required for all periods back until the period when the oldest-aged asset was new. Many assets, particularly buildings and structures, can have asset lives that can be measured in decades and in some cases even in hundreds of years. Few countries have input series covering the periods that would ideally be required. The alternative is to chose a distant point for which input series are available, with the point chosen by either assuming the capital stock at that point in time was negligible or using a 'jumping off' capital stock estimates that may have been derived as the result of some historical study.

21. The second drawback of the PIM approach is that it is heavily dependent on the assumptions used. Experience in Australia has shown that even relatively minor changes in assumptions can have significant impacts on the capital stock estimates generated, particularly those relating to the productivity dimension. So while contact with businesses may not be a feasible way to measure capital stock estimates directly, such contacts can often be a valuable source for establishing or testing the assumptions underlying the PIM.

22. The steps involved in applying the PIM are summarised in the diagram below:



(a) Expressed in the average prices of the reference year

23. Another useful output of the PIM is the average age of the gross capital stock at the end of each year, which can be used to show the extent to which an economy's capital stock is aging, or becoming younger, over time.

III. PIM ASSUMPTIONS

24. The key assumptions underlying the PIM relate to:

(a) mean asset lives;
(b) asset life distributions;
(c) the age-efficiency profile;
(d) the discount rate.

25. It should be recalled that as a consequence of the capital theory that underlies the Australian PIM, the age-price (depreciation) profile is derived from the age-efficiency profile, using the discount rate, and as such no explicit assumptions about this profile are required. However, the derived age-price results may be usefully tested against whatever information on the values of second hand assets is available, because significant differences could suggest concerns about the age-efficiency assumption.

25. In Australia, six data sources are used to derive mean asset lives:

(a) implicit tax lives;
(b) weighted prescribed tax lives;
(c) asset lives used by businesses to calculate depreciation for their own purposes;
(d) survival rates for vehicles in the motor vehicle fleet derived from the motor vehicle census;
(e) technical information on the operating lives of various types of machinery from manufactures' specifications;
(f) asset life estimates from other comparable overseas countries.

27. Judgment is used to meld the various data sources to determine the average asset life for each type of capital equipment. A concern is the extent to which asset lives for a particular type of asset may change over time. Generally, unless reasonable evidence is available indicating the contrary, asset lives are kept constant over time.

28. Within particular types of assets, variations in lives will occur because of different rates of use, maintenance, etc. Because of the lack of recent empirical evidence, asset life distribution curves developed by Winfrey[4] are generally used. Although the Winfrey study is old, it is empirically based. For a few intangible fixed asset types, other asset live distributions, based on asset specific information, are used.

29. Likewise, there is a lack of empirical data about the shape of age-efficiency functions, so the choice is a matter of judgement. The ABS has generally chosen to use hyperbolic functions, which is the same approach as that used by the US Bureau of Labour Statistics (BLS). In a hyperbolic function, the efficiency of an asset declines by small amounts at first, with the rate of decline increasing as the asset ages.

30. For discount rates, the ABS has chosen a real rate of 4%, the same as that used by the BLS and which approximates the average real 10 year Australian Government bond rate.

31. A more comprehensive description of the ABS's PIM is available in *Australian National Accounts: Concepts Sources and Methods* (Cat. No. 5216.0) (2000), available on the ABS website www.abs.gov.au.

IV. PROSPECTS FOR COLLABORATION TO IMPROVE COMPILATION

32. Australia is clearly not alone in its desire to compile high quality, comprehensive capital stock estimates in an integrated framework, and increasingly countries are interested in ensuring that the wealth and productivity dimensions of capital are compiled in a consistent and coherent fashion. In line with this, and given the complexities associated with capital stock measurement, there are a range of areas in which countries might collaborate:

(a) refinement of the capital theory on which the capital stock estimates are based;

[4] Winfrey R, *Statistical Analysis of Industrial Property Retirements*, Iowa State College of Agricultural and mechanic Arts, 1938.

(b) 'best practice' in the construction of PIMS;
(c) work on developing and testing the assumptions underlying the PIM, particularly those that are based on old studies and/or lack a robust empirical framework;
(d) understanding the application of the PIM to the new asset types in the SNA, such as R&D assets;
(e) sharing experience in direct measurement of capital stocks, where such measurement may complement the PIM or replace certain elements;
(f) working with accounting standards bodies to improve the quality of businesses'; capital stock estimates from the perspective of economic statistics.

33. Up until now, the forum for international work on capital measurement issues has been the Canberra Group[5]. The original Canberra Group developed the aforementioned *Measuring Capital* Manual. Canberra 2 has been active in addressing issues associated with updating the SNA, including the capitalisation of R&D. It is also actively involved in progressing the research issues identified in *Measuring Capital* and there is an advanced draft of a revised edition of the Manual. Notwithstanding this, however, there remains plenty of work to be done on aspects of measuring capital that could benefit from continued international collaboration. To progress some of these issues might require studies of significant magnitudes, and countries should be encouraged to invest in such studies and to share findings. While the Canberra Group has proven to be a reasonably effective mechanism for progressing capital issues – particularly in its bringing together of capital theoreticians and national accounts practitioners – it is a part-time, self selected group and consideration should be given to ensuring that the full range of countries is involved.

34. A related issue is the need to understand the implications for capital measurement in developing countries that lack the sophisticated statistical capability of countries such as Australia.

V. ISSUES FOR DISCUSSION

35. The following issues are suggested for discussion:

(a) The measurement of capital stocks is challenging. On the one hand, direct measurement is very difficult due to a paucity of observable data. On the other hand, using models such as the PIM have the drawback of being dependent on assumptions. The ABS has taken the approach that it is better to provide 'approximate answers to the right questions', rather than to avoid measurement. Our view is that statistical agencies are best placed to develop credible, transparent models that will stand up to scrutiny, partly because much of the data required to derive the estimates will generally only be available to statistical offices. Another reason for statistical offices undertaking the measurement is that capital stock estimates are required for a comprehensive set of national accounts, which is generally the domain of statistical offices. The issue of the how statistical offices should approach this type of work may merit discussion.

[5] The OECD is currently providing secretariat services for the Group, and Group meeting are normally chaired by an ABS representative.

(b) The paper outlines the broad approach adopted by the ABS in constructing capital stock estimates, which is based on an integrated theory of the wealth and productivity dimensions of capital. Is such an integrated approach supported, and is theoretical basis underlying the ABS approach seen as appropriate?

(c) The paper suggests some possible areas for international collaboration. Have the key areas been identified? What are the highest priority areas?

(d) The Canberra Group has played a major role in addressing capital stock measurement issues. Given that there remains a range of issues on which further work may be required, what should be the future of the Group? While it is considered that the Group has been reasonably effective in its work to date, should changes be made to the Group's operation to further enhance its effectiveness?

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