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MEASUREMENT OF CAPITAL STOCK IN CYPRUS

Supporting paper submitted by the Department of Statistics and Research,
Ministry of Finance of Cyprus*

Introduction

1.   In recent years the Cyprus economy has become more closely integrated with the international market. This is mainly due to the fact that Cyprus has experienced significant economic growth in certain economic activities. In order to analyze and control this growth, a sound statistical base is indispensable. This is one of the main reasons why the Department of Statistics and Research has recently improved its database, especially that of National Accounts. Whereas, traditionally, good information has been available on the labor force and its income i.e. wage and salaries, virtually no information existed about the other production factor, namely Capital. No information existed for instance on the amount and structure of Capital Stock. The calculation of Capital consumption has, so far, been based on rough assumptions.

2.   The aim of this study is to present the elaborated and more appropriate methodology implemented under the EUROSTAT project "Activity A10: Calculation of Capital Stock and Consumption of Fixed Capital".

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     *   Prepared by Mr. George Zeitountsian, Section of Industrial and Construction Statistics, Department of Statistics and Research.

3.   The project was undertaken by Cyprus within the EUROSTAT Pre-Accession Framework in order to improve the National Accounts in the candidate countries.

4.   The calculation of capital stock in Cyprus, the various problems encountered and the solutions given in the process, can be described as the main framework of this presentation. The various assumptions (average life expectancy, maximum life duration) on which this study has been based upon are also listed.

Capital stock definition

5.   Although the general definition of **Capital** in the manual refers to:
" …To all types of man-made goods and natural resources available in the country at a given point in time, for use in the production of goods and services, except for goods and services which are totally used up in the production process during the period of account."[1]

6.   In practice, however, for National Accounts purposes the concept of **capital stock** covers only the value of fixed capital assets available for production purposes at a given point in time. Hence it can be deduced that the boundaries of the capital stock in a given national economy are defined and determined by what is defined as "gross fixed capital formation", and how well that definition applies on the coverage of fixed assets in a country.

7.   Ideally **gross fixed capital formation** should cover both tangible (dwellings, buildings and other construction structures, machinery and equipment, transport means and equipment) and intangible fixed assets (mineral exploration, computer software, artistic originals, etc).

8.   In practice though in Cyprus, gross fixed capital formation was confined mainly to cover tangible assets and the major improvements associated with them. Only in the last year or two the definitional boarders were extended to incorporate some intangible assets like computer software, mineral exploration and artistic originals. However these additions are not yet incorporated in the present capital stock calculations.

9.   Thus capital stock in our case is defined as mainly the stock of fixed reproducible assets consisting of the following types:

a)   <u>Construction works</u>, that is residential (dwellings) and non-residential buildings of all kinds together with other civil engineering projects such as roads, dams, irrigation projects, harbors etc.

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[1] U.N Guidelines in Statistics of Tangible Assets, (New York: Statistical Papers, 1979), Series M, No. 68.

b)   Machinery and equipment, that is all kinds of machines from the giant thermoelectric turbine to the modest factory sewing machine. Furniture and equipment are also included under this broad type category.

c)   Transport equipment, that is all types of transport vehicles except the privately owned cars. Thus all kinds of passenger cars (taxis, buses, rented cars, etc), the vehicles for the transportation of goods, trains, ships and airplanes are included under this category.

10.   The concept of capital stock is further distinguished to Gross and Net Capital Stock.

11.   **Gross capital stock** represents the gross value of capital used in production at a given point in time. It represents the cumulative value of past investments less the accumulated retirements of capital goods. This is equivalent to the amount of fixed assets physically in operation in the nation's economy, i.e. those assets participating in the production process. No depreciation or loss in value is deducted. Meaning that the capital goods still in use are valued at prices as if they were new.

12.   **Net capital stock** represents the cumulative value of the past investments on fixed assets less the accumulated capital consumption. It is equivalent with the financial value of the gross capital stock. The value of the assets is calculated at prices, which they would, obtained if they were put on the market in their present state (used). These values are approximated by depreciation of the gross value during the lifetime of the asset.

13.   Finally when calculating Capital stock one should always keep in mind some important issues such as:

a)   **Capital consumption –** refers to the amount of fixed capital used up in current production, i.e. is the decline in the value of an asset as a result of age and utilization. From a financial point of view, capital consumption can be interpreted as the reduction of the market value of the capital stock during a period of time. In general is approximated by the linear distribution of the value of capital **goods over the period of their lifetime.** A necessary distinction should be made between capital consumption and **the commercial depreciation**, which according to accounting conventions is the distribution of the gross value of capital goods over **the expected medium lifetime**. This medium lifetime is defined for specific types of capital goods, and these averages are fixed according to tax regulations.

b)   **Retirements –** represent the gross value of capital goods, which are physically removed from the capital stock within a period of time. The removal can be due to technical reasons (breakdown, accidents, fire etc) or economic reasons (new technologies, technical substitutes, closure of factories). These removals are considered to be "normal" losses and their rate of retirement

during the maximum lifetime of a capital vintage can be estimated by statistical methods.

c)   **Special retirements –** represent the gross value of capital goods, which are physically removed from the capital stock due to the destruction of capital goods by wars and disasters and must be calculated separately.

The valuation of capital stock

General remarks

14.   When estimating the nation's capital stock the valuation problem always appears. Supposing that capital goods are valued at their "historical" prices prevailing at the time the goods were purchased (value of acquisition), then the gross capital stock will represent the sum of financial capital invested into the capital goods at the time of purchase.

15.   This means that when calculating capital stock one should compare the values of old and new assets. Nevertheless this is not as easy as it sounds. There is always the problem of vintages. When the standard of technology is very high it is virtually impossible to compare a machine made in 1980 with a machine made in 1990.[2]

16.   Sometimes in economic theory it can be assumed for reasons of simplicity that if innovation occurs all assets will perform at the same rate thus increasing productivity by the same amount. In practice though this does not happen. Only the new assets will benefit the maximum from the innovation.

The valuation used for national accounts

17.   The purchase value of an asset at the time of its acquisition is called **"historical"** and it's found in the accounts as the book value of that asset. Although the annual investment data are presented at historical values, the resulting investment series represent an amalgamation of different price levels, and unless some rational adjustments are made, cannot be used as a basis of estimating the value of capital stock.

18.   If capital stocks are calculated at acquisition cost, then the gross capital stock represents the sum of financial capital invested into the capital goods at the time of purchase. Net capital stock on the other hand is equal to

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[2] Some economists, particularly *J. Robinson* and *N. Kaldor* of the Cambridge University, are skeptical at to whether Capital can be measured as an aggregate, in order to produce together with Labor, aggregate Output. They also go a step further and distrust the idea that economists can work with a detailed breakdown of numerous heterogeneous capital goods, like different types of machines, to get quantitative results in a real mixed economy characterized by uncertainty and uneven economic

the accumulated expenditure on investment less the return of depreciation by cash flow. This valuation is close to the valuation of assets in the commercial balance sheets and can be used as financial indicator.

19.   Usually the data of assets in the commercial balance sheets can be obtained from censuses or special investment surveys, only at special circumstances and very rare. Nevertheless this kind of data, if obtained from reliable sources, can be used to check the consistency of stock estimates obtained with the aid of mathematical calculations. Consequently the original book-value estimates derived from a census can be compared with the figures calculated using a mathematical model (a perpetual inventory) in order to test the validity of the various exogenous parameters involved in the model.

20.   International practice has shown that capital stock estimates are meaningful if the valuation concepts used correspond to those used in the valuation of production. In national accounts this is called the **current replacement cost** concept or as it is otherwise known the cost of reproduction. It reflects the amount of money that would have to be paid if all the capital goods in the economy are valued at the price prevailing in the current year. The gross capital stock at current replacement cost assumes that all goods were purchased new in the year of observation. The net capital stock assumes that all goods were purchased in their present state (used assets) in the year of observation. As the value of capital goods purchased in previous years have to be revalued year by year, changes in the capital stock value appear as a new booking item in capital stock accounts.

21.   A third concept of valuation is the **constant replacement cost (constant prices)**. Like any other economic data capital stock can be valued at the prices of a selected base year. It should be noted, however, that the same base year should be chosen for both capital stock and gross output. Valuation at constant prices has the advantage of offsetting any problems associated with pricing old investment data at replacement cost. It is relatively easier to obtain capital stock estimates at this level of valuation and the results can be used when conducting comparative studies over a period of time. The gross capital stock at constant replacement cost, represent the value of fixed assets on the assumption that all goods were purchased in the base year. Similarly the net capital stock assumes that the assets in operation were purchased at their present condition at the prices of a selected base year.

Calculation attempts of capital stock in Cyprus

General

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growth. The views of these economists can be contrasted with the general neoclassical viewpoint expressed by *Samuelson, Solow* and others.

22.   Capital stock in international practice can be estimated in two ways, the direct and indirect approach.

23.   The direct approach deals with the enumeration of the whole nation's capital assets, by observing and recording their book values. This method was developed in the former Eastern Block countries where the book values of the various assets served as a base for their capital stock calculations. It is obvious that this is a very laborious and tedious procedure, which cannot be applied easily to countries with free market economies.

24.   In addition it should be stated that even if a capital stock census were to be held (irrespective of the cost and time constrains) in order to record the nation's fixed assets the whole procedure would still fail to produce the desired results. This is because in a free market economy the balance sheets of the various enterprises record their fixed assets on the cost of acquisition. Thus the results of such a survey will have a limited application in estimating capital stock, establishing only the lower boundary for the estimates.

25.   On the other hand the indirect approach estimates capital stock mathematically, using the annual investment data and some life expectancy assumptions. It is comparatively easier than the direct approach, less time consuming, and under the circumstances, the results are considered as being more reliable.

26.   One of the estimation methods using the indirect approach is the perpetual inventory (PIM).

Data and assumptions

27.   The first calculation attempt of estimating capital stock in Cyprus was conducted in 1985 on an experimental basis. Nowadays a second attempt is made under project **"Activity A10: Calculation of Capital Stock and Consumption of Fixed Capital"** in accordance with the harmonization with EUROSTAT directives. In both cases the procedure has followed some important considerations:

*   The choice of calculation approach
*   The availability of data
*   The availability of the estimation model
*   The availability of computer hardware and software

28.   Following the useful technical experience gathered from the experimental calculations of the capital stock for the year 1985, it was very natural to choose again the perpetual inventory method (PIM) for the project A10.

29.The data availability was partly solved up to 1985, although additional effort was needed to convert the existing investment series into the new base year.

30.   The greatest problem was the establishment of the estimation model since the one used in 1985 was "primitive" by today's standards. Fortunately the model **"Capital1.sas",** developed by Prof. Dr. Jörg Beutel, became available.

31.   The computer hardware and software availability was determined by the technical requirements of the model, i.e. a computer powerful enough to run the SAS package with the special module of IML (Interactive matrix language).

32.   The perpetual inventory method requires **investment series**, which have to be as long as the **maximum lifetime** of capital goods and calculates capital stocks as the sum of the **remaining parts** of all previous capital vintages.

33.   As a result the following had to be considered:

    1)   Time series of investment data
    2)   A survival function
    3)   Lifetime assumptions.

Time series of investment data

34.   The basic prerequisite for the calculation of capital stock according to the Perpetual Inventory method is the availability of long time series of investment data.

35.   In Cyprus due to the existence of a relatively good statistical database, it was not difficult to obtain data on investment for fixed assets, as back as 1960 for all the main categories of assets; namely Construction, Machinery and Transport.

36.   This was achieved after conducting a detailed examination of all the available national accounts from the year 1960 onwards. Prior to year 1960 no information existed on a systematic statistical basis, apart from very aggregated fixed capital formation figures scattered in the various English colonial official documents.

37.   The database from 1960 onwards provided rich information for the value of the investment, both at current (historical) and constant prices, and was also classified according to economic branch (ISIC classification) in Cyprus. The main problem at this stage was the reclassification of the old figures 1960-1980 (9 branches) into the present form of 14 branches. This was achieved with the detailed examination of the annual survey reports of each branch and the establishment of conversion keys. In the case of information that was hidden (aggregated) or non-existed, the structure of the subsequent years was used in the allocation process. As a general rule, the total investment figure for each asset category in the economy for a particular year remained unchanged. Thus the disaggregating procedure it was guaranteed not to produce additional estimation errors for the total economy.

38.   Since a **49-year** investment series was considered to be more than
satisfactory, at least for the categories of Machinery and Transport, the data
for those categories was only expanded up to the year 1950. Consequently all the
effort was concentrated on expanding the database for Construction. In order to
overcome this problem an expansion of the existing investment series was
attempted using a pattern of the international business fluctuations.[3] As a
result a long time series for Construction investments, from 1925 to 1999, at
both "historical" and constant prices was compiled.

39.   In order to verify the reliability of these **"artificial investment series"**
sensitivity tests were carried out. The tests showed that even if large
assumption errors were made during the initial period of the given time series
they could hardly affect the final results. The study revealed that even if the
original estimates were to be doubled for the first 15-year period, the results
for the capital stock in the recent years remain largely unchanged. This
suggests that the effect of estimation errors in the investment series is
reduced by the fact that the survival function shows decreasing values with the
length of its lifetime.

40.   Another important element in "favor" of the deliberate use of "artificial
investment series" is the unfortunate fact of the vast losses of capital stock
incurred due to the 1974 events and the consequent **de facto** division of the
island.

41.   The conversion of the investment time series from current (historical) to
constant prices was achieved by using various price indices as deflators. In
view of the present requirements, i.e. to make capital stock in line with Output
at constant 1990 prices, the decision for having the data at constant 1990
prices was taken. Since the data series were recorded at different base years a
linking process has been undertaken to chain the whole time period together.

42.   As far as investments in buildings and other construction projects were
concerned price indices for the various inputs were used. This procedure takes
into account the price increases for the main input components; labor cost,
construction materials, other expenses etc., weighted according to a base year
cost structure. This approach was adopted in the absence of more reliable
deflators.

43.   In the case of machinery and equipment, Laspeyres type price indices were
used for both domestic and imported capital goods. A similar procedure was used
for transport. In the later the weighted average market price of different types
of vehicles was used as a deflator, alongside with price indices of imported
transport equipment.

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[3] P. Samuelson, Economics (Singapore: McGraw-Hill, 1973), p. 250.

44.   The price indices were compiled by category of asset and branch for the years 1990-1999, whereas for the previous years the annual price change for the particular asset was used to extrapolate the existing price indices backwards by branch. The idea of using the existing implicit deflators (resulting from the division of the current and constant prices) was abandoned soon after examining the first results. This was primarily due to the very small numbers for each branch and to the rounding of the published figures to the first decimal.

The survival function

45.   In the capital stock calculations there is a direct reference to the distribution of the assets' lifetime, therefore a density function of a statistical distribution is regarded to be a suitable mathematical tool for the purposes of the perpetual inventory method.

46.   Capital stock experts recommend that for the estimation of the survival function of a capital vintage some sort of bell-shaped function have to be used. This is required as a capital vintage consists of a sum of various capital goods for which different lifetimes can be expected. The simultaneous exit of capital goods at the end of the maximum lifetime can only be assumed for a single capital good. A linear survival function does not consider the accumulation of exits around the medium lifetime.

47.   Empirical evidence for motor vehicles clearly reveals that the distribution of scrapping follows a symmetric shape. Moreover, the bell-shaped function reduces the range of errors efficiently. Tests of different survival functions revealed that the specific type of function has only limited effects on the results as long as it is a bell-shaped function.

48.   The mathematical formula of a bell-shaped survival function can be defined in different ways. Mainly the use of the normal, log-normal or gamma function is recommended.[4]

49.   Although that for the 1985 experimental calculations, the experience of the Federal Statistical Office in Germany was used by adopting the Gamma distribution probability density function[5], for the purposes of the present estimations the **log-normal** function of the **"Capital1.sas"** model was applied. This was necessary in the absence of any empirical evidence in Cyprus, regarding the values of the two parameters of the density function. In the present model the dispersion factor for construction is 2.0, for machinery and transport equipment 2.5.

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[4] See Johnson, N.I, Kotz, S. (1970): Distributions in Statistics – Continuous Univariate Distributions. Vol. 1, Wiley, New York.

[5] H. Lutzel, Estimates of Capital Stock by Industries in the Federal Republic of Germany (Review of Income and Wealth, 1977), Series 27, No. 1.

50.   The log-normal distribution has a positive skewness. For very small values
of sigma (high dispersion coefficients) it is very difficult to distinguish
between log-normal and normal distribution. As the function has a positive
skewness, the mode, the median and the arithmetic mean are not located in the
same position. The mode is in the highest position of the density function,
followed by median and then by the arithmetic mean.

51.   The function always starts with a zero probability in the investment year.
A cut is necessary on the right side of the distribution to exclude trifle
values from the calculations. Disadvantages of the distribution are the
complicated economic interpretation of the parameters of the distribution and
the requirement of longer time series of investment for the same dispersion
factor.

Lifetime assumptions

52.   As it was already mentioned, the crucial parameter of the survival
function is the estimation of the average length of time in each category of
assets.

53.   Prior knowledge of the age composition of fixed capital assets provides
useful information in capital stock calculations, since it can be used in the
establishment of technically correct **expected lifetime** for those assets.
54.   One method is the use of depreciation rates for tax purposes. However
these rates imply considerably shorter lifetimes, therefore some kind of
assumptions for their modification are required in order to arrive at a more
"realistic lifetime".[6]

55.   Another method is to either make ad-hoc surveys in order to enumerate
leading or "typical" enterprises from each of the main economic activities, on
specific types of capital equipment or to collect technical information on their
behavior from the various specialists on the field, namely importers of capital
equipment, producers of such equipment, engineer's etc.

56.   Given the time and money constrains to undertake any of the above
considerations, for the purposes of the present calculations the lifetime
assumptions incorporated in the **"Capital1.sas"** model were used.

57.   However after examining the first results (fluctuating lifetimes) it was
decided to use stable lifetimes for the entire period per branch for each of the
main category of fixed assets. Thus the most dominant lifetime per asset in each
branch was selected.

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[6] This is the method that was used in the former socialist countries. However as a rule they used to undertake detailed
statistical surveys on the age distribution of assets every 8 or 10 years. Based on the findings from these surveys the initial
assumptions on the expected lifetime were revised.

58.   Irrespective of the method used or the assumptions applied, sensitivity tests have to be applied, in order to check the behavior of these assumptions.

59.   Needless to say that in the absence of better estimates even such computations, which are based on "technically" inaccurate lifetime assumptions, are very welcomed and the ensuing results could still be very helpful.

Treatment of the 1974 losses

60.   As a result of the war in mid-1974, and the subsequent inaccessibility of the northern part of the island (due to the occupation of nearly 40% of land), an enormous amount of capital stock was either destroyed or is still inaccessible for the estimates of the economy.[7]

61.   In order to cope with the problem of losses the following treatment was adopted in the calculations:

   1)   For both practicality and simplicity reasons, it was assumed that the war took place as an event at the end of 1974.
   2)   It was decided to apply the same treatment for all the effects of the invasion whether these were actual war damages or losses of capital equipment resulting from the occupation.
   3)   The losses where treated as special retirements from the capital stock and assumptions where made for in each of the 14 economic activities according to the type of fixed assets.
   4)   The information on the approximate level of losses of capital assets in each economic branch were derived from official reports of that period and other academic sources.
   5)   The above percentages were deducted from the corresponding capital stock in the year 1974, for all three types of asset in each economic branch. Then on the remaining capital stock the annual difference was added. Thus from the year 1975 onwards the capital stock resulted according to the PIM were "corrected" from the invasion effects.

Concluding remarks

62.   Although the present project succeeded to give estimates for the capital stocks and the capital consumption thus fulfilling the short-term targets of the project **"Activity A10: Calculation of Capital Stock and Consumption of Fixed Capital"**, some shortcomings and methodological weaknesses that were encountered during the project, cannot be disregarded in the medium or long run.

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[7] Data on investment before 1974 refer to the whole of Cyprus, whereas the data from 1975 onwards refer to the investments made in the government controlled areas only.

63.   These points can be categorized as:

- Methodological
- Data weaknesses
- Time constrains

Methodological issues

64.   From the methodological point of view the main problem to be solved is the choice of the survival function and its parameters. It is obvious that the availability of the **"Capital1.sas"** model determined the choice of the survival function. Given that, it seems appropriate to experiment at least with the dispersion factor and the average lifetime of the assets using technical information on their behavior from the various specialists on the field. On the long run perhaps an investment survey could provide better information on the maximum lifetime of certain assets.

65.   Another methodological issue is the derivation of price series from the existing data at constant prices. The chain method is advocated to be a reliable method for the transformation of prices between two base periods. Still it can be argued that every base year has certain composition of homogeneous groups of assets that represent technical relationships and are unique for that period. In an environment of a dynamic and changing economy hardly the new base year can replicate the previous one. One cannot expect that the chain method could give meaningful results for the full extent of the investment series.

Data weaknesses

66.   During the capital stocks calculations some shortcomings were encountered relevant to the data sources. The most important one was the classification problems faced in respect to the reallocation according to the present classification status. Fixed capital formation unlike to the other national account variables was not given proper attention in the past and as a consequence it was presented in a very aggregated form in the survey reports.

67.   Furthermore the various assets were grouped together and many problems were encountered in order to establish the investment series for the three main categories of assets.

68.   Finally it was discovered that due to rounding some values of less than 0.05 mln were not presented in the national accounts time series, while for values of slightly greater than 0.05 mln, a figure of 0.1 mln was recorded in the tables.

69.   The absolute amount (0.05 mln) by today's standards could be negligible, but in the early years of the investment series could make the difference especially when such an amount is converted to current replacement cost. On the other hand if the figure were recorded in the investment series, it would mark the existence of that particular branch in the Cyprus economy.

Time constrains

70.   The first phase of the project was completed under extreme time pressure, which could not permit the adoption of "theoretically better" solutions in the context of data handling. Nevertheless, the working experience that was gathered in the data handling and the reallocation procedures with the development of special conversion keys could be proved very valuable for the future work on the project.

71.   The most laborious and time-consuming work was the transformation from the ISIC classification to NACE. This was completed on the A17 level. Nowadays work is proceeding from the year 1998 backwards and presently the investment series are available at the A60 presentation level for the period 1984-1998. Under this framework, investment series are developed for the category **"furniture and equipment",** alongside with the other three assets. Information was collected also for the investments on airplanes and ships. It is expected that on the medium term (year 2001) capital stocks estimates will be available with the NACE classification at the A30 presentation level, for the existing assets and furniture.

72.   Finally suffice is to say that I am aware that the method of estimating capital stock and capital consumption, set out in this study, is greatly influenced by the availability and the quality of existing data. Knowing these limitations, any constructive criticism is welcomed, hoping that it will provide an incentive for further research and creative analysis on the subject.