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Methodological Note on the Estimation of Capital Stock and Consumption of Fixed Capital Series.

National Accounts Benchmark 2021

Version March 31, 2026

1. Introduction

This methodological note summarizes the set of conceptual, technical, and supporting information choices adopted in the implementation of the new 2021 benchmark for National and Regional Accounts, regarding the series of capital stock and consumption of fixed capital. The methodological changes introduced are based on the OECD Measuring Capital Manual¹ (2009) and incorporate the conclusions of the Task Force (TF FIXCAP)² created by the Directors of Macroeconomic Statistics (DMES) of the EU, aimed at improving the coverage and robustness of statistics on fixed assets published under the ESA 2010 transmission program.

Most of the TF FIXCAP recommendations were incorporated into the revision process of the new 2021 benchmark for National Accounts. The methodological changes were defined to ensure adequate coverage of the information base on GFCF and price deflators, and to review the methodology for compiling the series of capital stock and consumption of fixed capital. The objective is to improve the consistency and international comparability of results within a framework of harmonized criteria, procedures, and common concepts across the European Union. Additionally, the changes also aimed to optimize the incorporation of relevant assumptions and criteria from the 2016 benchmark, considering the specificities of the national context.

The agreed FIXCAP recommendations refer to strengthening the Perpetual Inventory Method (PIM), which is the most widely used method for estimating capital stock and consumption of fixed capital (depreciation) within national accounts procedures. In the PIM model, capital stocks are quantified by accumulating flows of GFCF (Gross Fixed Capital Formation), valued at current prices, and adjusted for retirements of capital goods and consumption of fixed capital. This document describes the methodological options adopted in the new 2021 benchmark for National and Regional Accounts, covering:

- Definition of the main concepts involved in compiling the series of capital stock and consumption of fixed capital, as well as the analytical model adopted.
- Specification of the perpetual inventory method used to estimate gross capital stock, net capital stock, and consumption of fixed capital.
- Systematization of disaggregation criteria by industry, institutional sector, and categories of elementary fixed assets.
- Identification of price index series and parameterization of survival and depreciation functions that are now used.
- Definition of procedures for estimating the series of gross and net capital stock and the series of consumption of fixed capital.

¹ <https://www.oecd.org/sdd/productivity-stats/43734711.pdf>

² [DMES Task Force on Fixed Assets and Estimation of Consumption of Fixed Capital Under ESA 2010.](#)

The sensitivity analysis of the methodological changes made between the 2016 and 2021 benchmarks confirmed a structural break in the corresponding series of capital stock and consumption of fixed capital. Consequently, results were revised for the entire period from 1995 to 2022, as well as the capital stock estimates in the long-term time series of the Portuguese economy.

2. Definitions and Estimation Model

The estimation of capital stock and consumption of fixed capital series using the **Perpetual Inventory Method (PIM)** requires the availability of long time series of investment flows (GFCF), appropriate deflators for converting investment flows into volume terms, and the adoption of survival and depreciation functions for assets. The PIM is the method that enables the calculation of capital stock series by accumulating investment flows, adjusted for economic efficiency loss and asset survival factors, according to their life-cycle profile.

To estimate capital stock and consumption of fixed capital, the following inputs are required, as defined by ESA 2010 and OECD (2009):

- **Fixed assets (AN.11):** Produced non-financial assets³ that are used repeatedly or continuously in production processes for periods longer than one year. Fixed assets include dwellings, other buildings and structures, machinery and equipment, weapon systems, cultivated biological resources, and intellectual property products.
- **Gross fixed capital formation (P.51g):** Includes net acquisitions less disposals by resident producers of fixed assets during a given period, as well as other additions to the value of non-produced assets resulting from production activity.
- **Service life of assets:** The economic useful life of fixed assets, defined as the length of time they are expected to contribute to the production process.
- **Survival function of an asset (S(t)):** Represents the probability that a given capital good remains in use after a predetermined period t .
- **Depreciation function of an asset (D(t)):** Represents the loss of value of an asset due to age at a predetermined period t after installation. It is measured as the proportion of value lost from a new asset due to natural wear over time, obsolescence, or use, reflecting the rate of depreciation over its useful life.

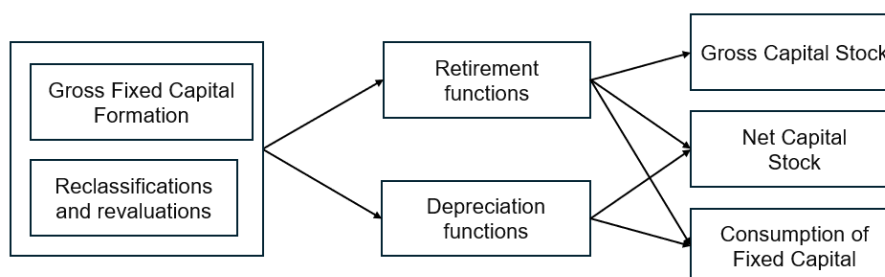
³ Produced non-financial assets (AN.1) consist of:

- Fixed assets (AN.11): Assets used continuously or repeatedly in production for periods longer than one year.
- Inventories (AN.12): Assets used in production as intermediate consumption, sold, or otherwise disposed of.
- Valuables (AN.13): Assets not primarily used in production or consumption, which are acquired and held mainly as stores of value.

- **Consumption of fixed capital (P.51c):** Represents the decline in the value of fixed assets held, because of normal wear and obsolescence, including provisions for losses due to insurable accidental damage. In national accounts, consumption of fixed capital is the term used for depreciation and is calculated for all fixed assets (except animals). It is treated as a production cost, as it measures the decline in the value of fixed assets attributable to their use in production.
- **Gross capital stock (GCS):** The stock of fixed assets that have survived from past investments, revalued at the current price⁴ of equivalent new capital goods. It is called gross because these assets are not deducted for consumption of fixed capital. GCS ignores asset depreciation and values past investments as “new” at current prices, deducting only decommissioned capital goods.
- **Net capital stock (NCS):** Corresponds to gross capital stock minus accumulated consumption of fixed capital. It is determined by the accumulated flow of investments in capital goods that remain in use, less accumulated consumption of fixed capital. The term “net” distinguishes the depreciated value of capital stock (NCS) from the non-depreciated value (GCS). Net capital stock is the relevant aggregate for wealth valuation and measuring the market value of capital.

The figure below illustrates the estimation model for gross and net capital stock and consumption of fixed capital, as required by the ESA 2010 transmission program:

Figure 1 – Estimation model for capital stock and consumption of fixed capital



Most countries use the standard PIM procedure to estimate gross capital stock, which relies on time series of gross fixed capital formation and corresponding reclassifications and revaluations, valued at the current price of new capital goods and filtered by survival functions that measure the proportion of accumulated fixed assets still in use. Consumption of fixed capital is estimated by applying depreciation functions that reflect the loss of asset value due to wear and obsolescence. Net capital stock is obtained for a given period by deducting accumulated consumption of fixed capital from gross capital stock over the service life of assets still in use.

⁴ In practice, the price index of GFCF for the respective asset/product, as determined by the National Accounts for the year, is used.

3. Breakdown by Fixed Asset, Institutional Sector, and Industry

The criteria for disaggregation by fixed asset, institutional sector, and industry were defined in accordance with the transmission program requirements of ESA 2010, as well as to address statistical development challenges, particularly within the productivity and growth accounting system. Within this framework, classification criteria were established by type of fixed asset, institutional sector, and industry, to be used in compiling and disseminating capital stock and consumption of fixed capital series.

Regarding the classification criterion by type of fixed asset, the structure shown in **Table 1** was adopted. This table reflects the hierarchical categorization of fixed assets adopted in the application of PIM for dissemination purposes. It also includes parameters characterizing the life cycles of elementary assets: average and maximum service lives.

Table 1 - Assets and Service Lives for PIM Implementation (Benchmark 2021)

Code	Asset description	Average life	Maximum life
AN.111	Dwellings	70	140
AN.1121.1	Warehouses and industrial buildings	30	60
AN.1121.2	Commercial, educational, health, military, and other service buildings	50	100
AN.1122	Other structures (bridges, roads, ports, parking lots, etc.)	55	110
AN.1131.1	Trains	25	50
AN.1131.2	Commercial ships	25	50
AN.1131.3	Commercial aircraft	20	40
AN.1131.4	General transport equipment	10	20
AN.11321	Computer equipment	6	12
AN.11322	Radio, TV, and communication equipment	5	10
AN.1139.1	Machinery and equipment (mainly CPA28)	20	40
AN.1139.2	Electrical equipment and furniture	15	30
AN.114.1	Military aircraft and helicopters	25	50
AN.114.2	Military ships and submarines	25	50
AN.114.3	Military combat vehicles	20	40
AN.114.4	Weapons and other military machinery and equipment	15	30
AN.1151	Animal resources that regularly produce goods	10	20
AN.1152.1	Stone fruit and pome fruit plantations	20	40
AN.1152.2	Kiwi and semi-tropical plantations	15	30
AN.1152.3	Citrus plantations	30	60
AN.1152.4	Vineyards and olive groves	45	90
AN.1152.5	Forestry plantations	15	30
AN.1171	Research and development	10	20
AN.1173	Software and databases	5	10
AN.1170	Originals and other intellectual property products	7	14

A second disaggregation criterion for producing and disseminating capital stock and CFC series relates to **resident institutional units**, defined in ESA 2010 as economic entities with autonomy in decision-making regarding their principal function within the economic territory where they have their predominant center of interest.

Data are broken down by the activities of resident institutional sectors and their corresponding subsectors, as shown in **Table 2**.

Table 2 - List of Resident Institutional Sectors

Code	Institucional sectors		
S.11	Non-financial corporations		
S.12	Financial corporations	S.121	Central bank
		S.124	Investment funds (excluding money market funds)
		S.127	Captive financial institutions and lenders
		S.129	Pension funds
		S.120	Other financial subsectors
S.13	General government	Market	
		Non-market	
S.14	Households		
S.15	Non-profit institutions serving households		

The third disaggregation criterion concerns the distribution of capital stock and CFC by industry, according to the two-digit classification of economic activities (CAE), corresponding to 82 branches (A82), as listed in Annex 1 – Classification A82 of economic activity branches (CAE-Rev.3).

4. Perpetual Inventory Method

For a given fixed asset, industry, and institutional sector, the gross capital stock (GCS) at the end of year t equals GCS in year $t-1$, plus reclassifications and revaluations (RR), plus gross fixed capital formation (GFCF), minus retirements (RT) of fixed assets occurring in year t , all valued at current prices of year t :

$$GCS_t = GCS_{t-1} + RR_t + GFCF_t - RT_t \quad (1)$$

Under the Perpetual Inventory Method, the gross capital stock at the end of year t results from the sum of gross fixed capital formation in previous periods, plus reclassifications and revaluations, minus retirements of fixed assets, all at current prices of period t . In other words, it is the sum of fixed capital investment that remains in use in the production process.

The gross capital stock can also be obtained using the following expression:

$$NCS_t = \sum_{j=0}^L (I_{t-j} - A_{t-j}) = \sum_{j=0}^L I_{t-j} \times S_j \quad (2)$$

Where:

$$I_{t-j} = (GFCF_{t-j} + RR_{t-j}) / IP_t^{t-j} \quad (3)$$

and

$$RT_{t-j} = I_{t-j} \times (1 - S_j) \quad (4)$$

Being:

- I_{t-j} : GFCF plus reclassifications or revaluations in year $t-j$, expressed at prices of year t .
- IP_t^{t-j} : Price index of the asset in year $t-j$, based on year t .
- S_j : Proportion of fixed assets acquired in year $t-j$ that remain in use in year t , i.e., j years later.
- ASL: Average service life of the fixed asset.
- $L = 2 \times ASL$: Maximum number of years considered for the asset's useful life, i.e., twice the average service life.

Expression (2) represents the gross capital stock as the sum of fixed capital investments made in previous periods that are still in current period. It is important to note that the number of years considered for the cumulative sum of fixed capital investments is limited to $L=2ASL$, instead of $+\infty$. This prevents assets from remaining indefinitely in the capital stock, by assuming that their value becomes negligible when ($j > L$).

The proportion of fixed assets acquired in year $t-j$ and still in use in year t is measured by factor (S_j). Thus $1-S_j$ represents the proportion of assets acquired in $t-j$ that have been retired in year t .

5. Log-normal Survival Function

To calculate S_j , it is assumed that this proportion results from a log-normal survival function, which is based on the **log-normal probability density function**, defined as follows:

$$f(x) = \frac{1}{x\sigma\sqrt{2\pi}} e^{-\frac{(\ln(x)-\mu)^2}{2\sigma^2}}, \quad x > 0 \quad (5)$$

Where

- x represents the number of years of the asset's life corresponding to $j=1, 2, \dots, L$.
- μ represents the mean of the log-normal distribution, which is given by

$$\mu = \ln(m) - \sigma^2/2 \quad (6)$$

- σ represents the standard deviation of the log-normal distribution, which is given by

$$\sigma = \sqrt{\ln\left(1 + \left(\frac{s}{m}\right)^2\right)} \quad (7)$$

Since variable x follows a log-normal distribution, if $\ln(x)$ is normally distributed, the parameters m and s in the above expressions represent:

- m = mean of the normal distribution corresponding to $\ln(x)$;
- s = standard deviation of the normal distribution corresponding to $\ln(x)$.

Regarding these two parameters:

- m corresponds to the average service life of the asset, as shown in **Table 1 - Assets and Service Lives for PIM Implementation (Benchmark 2021)**;
- s usually takes a value between $m/2$ and $m/4$, depending on the desired degree of flattening of the distribution curve.

The factor that determines how m is distributed is called the **dispersion coefficient**. Most countries adopting log-normal survival functions use a dispersion coefficient equal to 3, which is also the option adopted in Portugal. Thus, in the Portuguese case, the parameter $s = m/3$.

The log-normal survival function corresponding to the log-normal density function (5) is represented by the following expression:

$$F(x) = \int_0^x f(x)dx \quad (8)$$

The proportion of fixed assets acquired in year $t-j$ still in use in year t is obtained by **applying the survival function** (8), where:

- **For year $j=x>0$, $S_j = F(x)$;**
- **For year $j=0$, $S_0=1$.**

Based on these results, it is possible to operationalize equation (2), and estimate the gross capital stock for year t at current prices.

6. Estimation of Gross Capital Stock at Current and Previous Year Prices

The **gross capital stock at current prices** is calculated using expression (2), valued at the prices of the reporting year t , with the price index given by IP_t^{t-j} , which normalizes asset prices in year $t-j$ to the base of the current year t .

Additionally, the **gross capital stock at previous year prices** is also calculated, valued at the prices of the year preceding the reporting year ($t-1$). This is quantified using an expression equivalent to equation (2), but replacing equation (3) (which converts investment in fixed assets to prices of the reporting year t) with equation (9) below, which performs this conversion to prices of year $t-1$, based on the price index by IP_{t-1}^{t-j} :

$$I_{t-j}^{pyp} = (GFCF_{t-j} + RR_{t-j})/IP_{t-1}^{t-j} \quad (9)$$

Alternatively, the gross capital stock at previous year prices in year t (GCS_t^{pyp}) can be obtained using the following expression:

$$GCS_t^{pyp} = GCS_t / IP_t^{t-1} \quad (10)$$

Where IP_t^{t-1} is the price index of the asset in year t based on the current year t.

7. Geometric Depreciation Function

Regarding the evolution of the market value of assets, it is assumed that this value declines at a constant rate, following a geometric depreciation function. The depreciation factor (δ) was defined using the **double-declining balance method**, where:

$$\delta = 2/ASL,$$

subject to the restriction that asset depreciation is carried out over its average service life (ASL), ensuring that the final balance is zero.

Since, under a geometric depreciation structure, the value of assets declines asymptotically toward zero but never fully reaches it, an adjustment is made to the geometric depreciation rate so that the residual value, calculated at the end of the depreciation period (ASL), is distributed uniformly across the various depreciation periods. The **adjusted geometric depreciation function** is given by the following expression:

$$D_j = \delta \times (1 - \delta)^{j-1} + (1 - \delta)^{ASL} / ASL \quad \forall j = 1, 2, \dots, ASL \quad (11)$$

For $j=0$, it is assumed that $D_0 = 0$.

8. Estimation of Consumption of Fixed Capital at Current and Previous Year Prices

Consumption of Fixed Capital (CFC) measures the economic depreciation of the stock of fixed assets as result of physical deterioration, technical obsolescence, and accidental damage. It is valued both at current prices and at previous year prices. CFC represents the amount that would need to be invested to maintain the asset value constant. In national accounts, it is treated as a production cost, as it reflects the decline in the value of fixed assets attributable to their use in the production process.

CFC at current prices is calculated at the prices of the reporting year (t), based on the series of investment in fixed capital calculated using equation (3), with the price index given by IP_t^{t-j} , which normalizes asset prices in year t-j to the corresponding value in the current year t, using the following expression:

$$CFC_t = \sum_{j=0}^L I_{t-j} \times S_j \times D_j \quad (12)$$

Where

- I_{t-j} = GFCF plus reclassifications or revaluations in year $t-j$, expressed at prices of year t .
- S_j = proportion of fixed assets acquired in year $t-j$ that remain in use in year t , as described in section 5. Log-normal Survival Function.
- D_j = depreciation function applied to the asset cohort, as defined in section 7. Geometric Depreciation Function.

Additionally, the **consumption of fixed capital at previous year prices** is also calculated, valued at prices of year $t-1$. This is quantified using an expression equivalent to equation (12), but replacing equation (3), which converts investment into fixed assets at current year prices (t), with equation (9) above, which performs this conversion at $t-1$ prices, based on the price index IP_{t-1}^{t-j} .

Alternatively, the **consumption of fixed capital at previous year prices** in year t (CFC_t^{pyp}) can be obtained using the following expression:

$$CFC_t^{pyp} = CFC_t / IP_t^{t-1} \quad (13)$$

Where IP_t^{t-1} is the price index of the asset in year $t-1$, based on the current year t .

9. Estimation of Net Capital Stock at Current Prices and at Previous Year Prices

The standard PIM approach allows for the estimation of the gross capital stock, the application of a depreciation function to calculate the consumption of fixed capital, and the estimation of the net capital stock- by subtracting the accumulated fixed capital consumption from the gross capital stock.

The net capital stock at current prices (NCS) is quantified at prices of the reference year (t), by applying the price index given by IP_{t-1}^{t-j} , which normalizes asset prices in year $t-j$ to the value of the current year t , in order to obtain the investment series at current prices as defined in equation (3). This calculation can be performed using the following expression:

$$NCS_t = NCS_{t-1} + I_t - CFC_t \quad (14)$$

Or, based on the alternative formulation given by:

$$NCS_t = \sum_{j=0}^L I_{t-j} \times S_j \times \left(1 - \sum_{h=0}^j D_h\right) \quad (15)$$

Where

- I_{t-j} : GFCF plus reclassifications or revaluations in year $t-j$, expressed at prices of year t .
- S_j corresponds to the proportion of fixed assets acquired in year $t-j$ that remain in use in year t , as described in **Section 5. Log-normal Survival Function**.

- D_j corresponds to the adjusted geometric depreciation function, as defined in **Section 7. Geometric Depreciation Function**.

Additionally, the **net capital stock at previous year prices** is also calculated, valued at prices from the year $t-1$. This is quantified using an expression equivalent to equation (15), but replacing equation (3), which converts investment into fixed assets at current year prices (t), with equation (9), which performs this conversion at $t-1$ prices, based on the price index IP_{t-1}^{t-j} .

Alternatively, the **net capital stock at previous year prices** in year t (NCS_t^{pyp}) can be obtained using the following expression:

$$NCS_t^{pyp} = NCS_t / IP_t^{t-1} \quad (16)$$

Where IP_t^{t-1} is the price index of the asset in year $t-1$, based on the current year t .

Annexe 1 - A82 Classification by Economic Activity Branches (CAE-Rev.3)

Table 3 - A82 Classification by Economic Activity Branches (CAE-Rev.3)

A82	Description
01	Crop and animal production, hunting and related service activities
02	Forestry and logging
03	Fishing and aquaculture
04	Mining and quarrying
10	Manufacture of food products
11	Manufacture of beverages
12	Manufacture of tobacco products
13	Manufacture of textiles
14	Manufacture of wearing apparel
15	Manufacture of leather and related products
16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
17	Manufacture of paper and paper products
18	Printing and reproduction of recorded media
19	Manufacture of coke and refined petroleum products
20	Manufacture of chemicals and chemical products
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
22	Manufacture of rubber and plastic products
23	Manufacture of other non-metallic mineral products
24	Manufacture of basic metals
25	Manufacture of fabricated metal products, except machinery and equipment
26	Manufacture of computer, electronic and optical products
27	Manufacture of electrical equipment
28	Manufacture of machinery and equipment n.e.c.
29	Manufacture of motor vehicles, trailers and semi-trailers
30	Manufacture of other transport equipment
31	Manufacture of furniture

Table 3 - A82 Classification by Economic Activity Branches (CAE-Rev.3)

A82	Description
32	Other manufacturing
33	Repair and installation of machinery and equipment
35	Electricity, gas, steam and air conditioning supply
36	Water collection, treatment and supply
40	Sewerage; Waste collection, treatment and disposal activities; Remediation activities and other waste management services
41	Construction of buildings
42	Civil engineering
43	Specialised construction activities
45	Wholesale and retail trade and repair of motor vehicles and motorcycles
46	Wholesale trade, except of motor vehicles and motorcycles
47	Retail trade, except of motor vehicles and motorcycles
49	Land transport and transport via pipelines
50	Water transport
51	Air transport
52	Warehousing and support activities for transportation
53	Postal and courier activities
55	Accommodation
56	Food and beverage service activities
58	Publishing activities
59	Motion picture, video and television programme production, sound recording and music publishing activities
60	Programming and broadcasting activities
61	Telecommunications
62	Computer programming, consultancy and related activities
63	Information service activities
64	Financial service activities, except insurance and pension funding
65	Insurance, reinsurance and pension funding, except compulsory social security
66	Activities auxiliary to financial services and insurance activities
68	Real estate activities
69	Legal and accounting activities

Table 3 - A82 Classification by Economic Activity Branches (CAE-Rev.3)

A82	Description
70	Activities of head offices; management consultancy activities
71	Architectural and engineering activities; technical testing and analysis
72	Scientific research and development
73	Advertising and market research
74	Other professional, scientific and technical activities
75	Veterinary activities
77	Rental and leasing activities
78	Employment activities
79	Travel agency, tour operator reservation service and related activities
80	Security and investigation activities
81	Services to buildings and landscape activities
82	Office administrative, office support and other business support activities
84	Public administration and defence; compulsory social security
85	Education
86	Human health activities
87	Residential care activities
88	Social work activities without accommodation
90	Creative, arts and entertainment activities
91	Libraries, archives, museums and other cultural activities
92	Gambling and betting activities
93	Sports activities and amusement and recreation activities
94	Activities of membership organisations
95	Repair of computers and personal and household goods
96	Other personal service activities
97	Activities of households as employers of domestic personnel
98	Undifferentiated goods- and services-producing activities of private households for own use
99	Activities of extraterritorial organizations and bodies