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ESTIMATES OF CONSTRUCTION INFRASTRUCTURE STOCK FOR CAPE VERDE: 1980–2019

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Abstract. Building and other construction assets constitute a significant part of a country's physical and economic infrastructure. According to several writers, the knowledge of reliable data of building and other construction assets of a specific country or region is a crucial element for the long-term management of these assets. Built capital stock statistics at the national or international levels have been available for most countries of the world, both developed and less developed ones, for some time, but construction infrastructure stock statistics at the disaggregated level are very scarce, even for most developed countries. Furthermore, the methodologies to produce the estimates of built capital stock, at the international level, do not consider countries' specificities. This paper discusses the methodologic issues for producing construction infrastructure stock statistics for Cape Verde, and makes estimates for the period 1980–2019. The paper outlines the Perpetual Inventory Method (PIM) used to produce capital estimation, data employed, and the assumptions made to estimate missing data. The paper analyses the level of the construction infrastructure stock estimates for Cape Verde, as well as their impact on the development pattern of the country's construction industry, and suggests how further studies can enhance our comprehension of the relationship between construction investment and economic growth and development.

Keywords: built capital stock, construction infrastructure stock, construction sector, construction investment, estimation, Perpetual inventory method.

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1. Introduction

Building and other construction assets constitute a significant part of a country's physical and economic infrastructure. Infrastructure development plays a key role into production and wealth generation. The economic impact can be transformative, especially at lower levels of income per capita (Organisation for Economic Co-operation and Development [OECD], 2013). As pointed out by Maddison (1987), the close association between physical capital and different measures of national economy is one of the reasons why physical infrastructure has been considered a powerful engine of economic growth and development.

Quantitative assessments of the contribution of infrastructure to aggregate output was pioneered by Aschauer (1989) on the effects of public infrastructure capital on U.S. total factor productivity. Since then, a number of studies dealing with infrastructure investment-economic growth relationship, using a variety of data and methodologies, has provided widely contrasting empirical results (De Long & Summers, 1991; Easterly & Rebelo, 1993; Calderón et al., 2015; Kodongo & Ojah, 2016; Ansar et al., 2016; Banerjee et al., 2020; Meng et al., 2023) (for a detailed review, see Calderón et al., 2015; Banerjee et al., 2020). Calderón et al. (2015) used an infrastructure-augmented production function approach to consider the contribution of infrastructure capital to aggregate productivity and output. Their panel data set consisted of 88 developed and developing countries, over the period 1960–2000. They found that marginal product of infrastructure was higher when the (relative) infrastructure stock was lower but then diminished at higher levels. Kodong and Ojah (2016) analysed the relationship between infrastructure and economic growth, for a panel of 45 Sub-saharan African (SSA) countries, over the period 2000–2011. They found that it is the spending in infrastructure and increments in the access to infrastructure that influence economic growth and development in SSA. Meng et al. (2023) examined the eventual impact of the Chinese Government's massive post-2008 global crisis stimulus package on the downturn in the economy.

They distinguished between the effects of "traditional" and "new" infrastructure and found that it is "traditional" infrastructure, which provides the stronger effect as an engine of growth with longer-term benefits. Goldfarb and Tucker (2019), however, provided evidence that investment in various types of "new" infrastructure have had a positive effect on the productivity of enterprises, by reducing the cost of storage, computation and transmission of data. This aspect is very pertinent in the context of construction infrastructure development. Thus, investment in new technologies by different stakeholders participating in the development of these facilities can enhance the efficiency of resource allocation throughout all stages of the construction process. In a contrasting view of the infrastructure investment-economic growth relationship, Ansar et al. (2016) examined the effect of infrastructure investment on the economic growth in China, over the period 1984–2008. They reported that overinvestment in underperforming projects in China did lead to economic fragility. The study also suggested that a massive programme of infrastructure investment is not a viable development programme for other developing countries, which may look to China as a model for development. In the same line, Banerjee et al. (2020) analysed the effect of access to transportation networks on regional economic outcomes over a twenty-year period (1986–2006) of rapid income growth in China. They concluded that proximity to transportation networks have a moderately sized positive causal effect on per capita GDP levels across sectors, but no effect on per capita GDP growth. The World Bank's *World Development Report 1994* (World Bank, 1994) documented substantial cross-country differences in the efficiency with which public infrastructure is used. According to this line, it could be argued that productivity of public capital would be improved through adequate maintenance and upgrading of existing infrastructure stock and by prioritising investments that modernise production and enhance international competitiveness. A central question is, then, which is the level of infrastructure stock needed for an efficient functioning of the economy. Global Infrastructure Hub (2017, 2018) modeled the "relative investment need" for 50 countries across the globe, spanning much of the development spectrum, through up 2040. "Relative investment need" was defined as the "the extent and provision of infrastructure, across all sectors, such that countries match the performance of their best performing peers in terms of the resources they dedicate to infrastructure investment, after controlling for the specific economic and demographic characteristics of each country" (Global Infrastructure Hub 2017, 2018). The starting point to forecast values of investment spending through up 2040 was to estimate the infrastructure stock per person, in 2015, for all 50 countries.

A particular feature related with the role of infrastructure in the process of development is a trend of deindustrialization in the majority of developing countries, particularly in Latin America and SSA, since the 1980s. This phenomenon is known as "premature deindustrialization". Using data drawn from the Groningen Growth and Development Centre (GGDC) 10-Sector Database, Rodrik (2016) found that developing countries, with some exceptions, confined largely to Asia, have experienced falling manufacturing shares in both employment and real value added, especially since the 1980s. And since 1990, developing countries have reached peak manufacturing employment at incomes per capita that are around a third of the levels experienced before 1990. For manufacturing value added at constant prices, the corresponding ratio is less than a half.

This mixed results on the infrastructure investment-economic growth relationship bring to the fore the issue of infrastructure financing. Calderón et al. (2015) pointed out that, in contrast with the effort devoted to quantify the output impact of infrastructure, research has paid much less attention to the costs of infrastructure development as well as to the impact of the quality of infrastructure. Infrastructure typically involves large up-front investment, while benefits may take decades to accrue. This brings to the equation the link between financial constraints of government and involvement of external financing agents and how the nature of this situation affects the level and performance of investment (Straub, 2008). Government financial constraints are typical in low- and lower-middle income countries, which need to balance investment in infrastructure with investment in other sectors of the economy, such as health and education. Cape Verde is a case in point. Its economy is heavily dependent on tourism (25% of GDP in 2019), remittances and foreign direct, which are extremely vulnerable to external shocks. Furthermore, official development assistance to the country has declined from 18.7% of GDP in 2010 to 8.6% of GDP in 2021 (World Bank, 2023b). A seminal study on the diagnostics of infrastructure development in SSA (World Bank, 2017) reported that growth in GDP per capita would increase by an estimated 1.7 percentage points per year if it were to close the gap with the regional median (excluding SSA). Eliminating the quantity gap would bring about 1.2 percentage points higher growth per capita per year; catching up in quality would deliver 0.5 percentage points higher growth per year. The growth effects of the quantity of infrastructure vary by sector, with the largest growth benefits obtained by narrowing the gap in electric power capacity (0.7 percentage points higher per year). For the growth effects of quality, improving road quality provides the largest benefits.

As pointed out long ago by Stern (1991), research on growth accounting has been stimulated by and has stimulated the documentation and analysis of the empirical growth process by economic historians and statisticians. Important contributions have come from a particularly valuable set of data, which has provided re-computations of national income and physical capital on the basis of purchasing power parity (PPP). For over four decades, the Penn World Table (PWT) has been a standard source of data on national and international economies (Feenstra et al., 2015). Making use of prices collected across countries in benchmark years by the International Comparisons Programme (ICP) and using these prices to construct PPP exchange rates, PWT converts national economic data to a common currency ($US) allowing inter-country comparisons. The latest version of the PWT (version 10.1) (Feenstra et al., 2015) is a database with information on relative levels of income, output, capital and productivity, covering 183 countries between 1950 and 2019. However, like other international databases that produce capital stock statistics, the PWT does not present construction infrastructure stock statistics in separate format. Furthermore, their approaches for producing capital estimation do not take into account country-specific information. Thus, studies on the measurement of infrastructure stock for individual countries will certainly add to our understanding of the relationship between infrastructure investment and economic growth and development. This paper intends to contribute to this body of knowledge. It discusses the methodologic issues for producing construction infrastructure stock statistics for Cape Verde, and makes estimates for the period 1980–2019, using data from dispersed material drawn from Cape Verde's National Statistical Office.

The remainder of the paper is organized as follows: next section discusses the measures of construction assets and outlines the Perpetual Inventory Method (PIM) used to calculate capital estimation; an overview of Cape Verde's infrastructure development is presented in Section 3. Section 4 presents the data used for the study, the techniques used to fill missing data and the data sources. The estimates of construction stock for Cape Verde, for the period 1980–2019, and a discussion of the main results are presented in Section 5 and; a concluding remark finalises the analysis presented in the study.

2. Methodology

2.1. Measures of infrastructure assets

Investment in construction infrastructure is a component of gross fixed capital formation (GFCF). According to the United Nations' System of National Accounts (SNA) 2008 (United Nations, 2009), GFCF consists of the purchase of goods (and services) that are used in production for more than one year. This publication classifies capital stock statistics according to: type of assets; institutional sectors; and economic sectors as described in the International Standard Classification of Economic Activities (ISIC revision 4) (United Nations, 2008). The SNA 2008 identifies five institutional sectors: households; non-financial corporations; financial corporations; non-profit institutions serving households (NPISR) and; general government. In terms of type of assets, the built capital stock is comprised of: dwellings; and other buildings and structures (including land improvements). It is worth noting that major improvement to dwellings and other building and construction infrastructures is also accounted for as built assets (United Nations, 2009). Other fixed assets that are recognized in both the European System of Accounts (ESA) 2010 (Eurostat, 2013) and SNA 2008 are: machinery and equipment and weapon systems; cultivate biological resources and; intellectual property products (Table 1).

Table 1. List of asset types (United Nations, 2009)

Gross fixed capital formation
Total construction
Dwellings
Other buildings and structures
Buildings other than dwellings
Other structures
Land improvements
Machinery and equipment and weapon systems
Transport equipment
Information and Communications Technologies (ICT) equipment
Computer hardware
Telecommunications equipment
Other Machinery and equipment and weapon systems
Cultivate biological resources
Cost of ownership transfer of non-produced assets
Intellectual property products (IPP)
Research and development
Mineral exploration and evaluation
Computer software and databases
Other IPP

Capital stock of an economy is the accumulation through time of those assets. This indicator can be expressed as gross capital stock (which does not take depreciation of assets into account) or net capital stock, which is part of an economy's balance sheet in the context of income and wealth accounting. In order to evaluate a country's level of infrastructure stock, it is necessary to define what constitutes infrastructure and the role of the construction industry in delivering this infrastructure. As a World Bank report put it, what is meant for infrastructure has evolved. It is now defined as a complex array of capital goods that provide services in combination with other inputs (World Bank, 2017). Infrastructure can be classified into economic and social. Social infrastructure includes different sectors such as health, education, commercial, and security or defense. Economic infrastructure refers to large physical networks that are needed to promote economic activity, and is typically divided into five sectors: transport, telecommunications, energy, water and sanitation, and solid waste (World Bank, 2017). The UK Office for National Statistics [ONS] in *Experimental Comparisons of Infrastructure across Europe* (ONS, 2019) indicated that there is no universally accepted definition of infrastructure, and it is not separately identified in any national accounts data. Eurostat's estimates of infrastructure for European Union countries are based on the stock of "other structures" asset from national balance sheets. This is a reasonable predictor of infrastructure stock, although it contains some assets that are not related to infrastructure while leaving out some that are (L. Ruddock & S. Ruddock, 2022). Expenditures in infrastructures refer to "structures other than buildings, including the cost of the streets, sewer site clearance and land preparation" (United Nations, 2009). In Cape Verde's National Accounts, the definition of "civil engineering and other works" is compatible with SNA 2008's definition of "other structures".

2.2. Perpetual inventory method

International organisations that produce databases on capital stock statistics (Feenstra et al., 2015) and research works dealing with these statistics (Kamps, 2006; Berlemann & Wesselhöft, 2014; Derbyshire et al., 2013; Lopes et al., 2019) have employed the PIM methodology outlined in the two editions of the OECD Manual – *Measuring Capital* (OECD, 2001, 2009). The PIM, as implied by its name, interprets a country's fixed capital stock as an inventory (Berlemann & Wesselhöft, 2014). This methodology involves accumulating past gross fixed capital formation and deducting the value of assets that have reached the end of their service lives. Both capital formation and discards of assets are revalued either to the prices of the current year (current prices) or to the prices of a single year (constant prices).To estimate the total capital stock, the following data and assumptions, broken down by type of asset, are required: a sufficiently long time series of data on fixed investment; a sufficiently long time series of price indices (deflators); information on initial capital stock at the time when the time series of investment start; assumptions regarding the average service lives and depreciation function of the relevant assets.

One critical aspect of the PIM methodology is the setting up of the depreciation method to account for the writing-off of consumed fixed capital. In the straight-line depreciation method, the consumption of fixed capital is linear in nature. The corresponding mortality function is the "simultaneous exit", i.e., an asset is removed from the capital stock when its value has depreciated to zero in the final year of its service life. However, OECD (2009) suggested that simultaneous exit is not a realistic retirement pattern and suggests that other retirement patterns that assume a certain bell-shaped function around the average age of retirement are more realistic. Another common model is geometric or declining balance depreciation. It has been used in a large number of economic studies and is also gradually adopted by statistical agencies (OECD, 2009).

An important feature of the geometric model is that the factor of proportionality becomes independent of the vintage of the asset. The implication is that the value of depreciation does not have to be computed separately for every vintage but is obtained directly by applying the rate of depreciation to the net capital stock. The geometric model of depreciation, δ, has sometimes been estimated with the "declining balance method", and on the basis of information about average service lives of a group of assets. Hulten and Wykoff (1996) suggested converting the average service life of a cohort, *TA*, into a depreciation rate based on the "declining balance" formula $\delta = R/TA$ where R is an estimated declining-balance rate. According to OECD (2009), a value of R in the range from 1.5 to 2 is usually chosen.

Given the net stock at the beginning of the first period, end-period net stocks for all consecutive periods are set up by applying the stock-flow relationship, as shown in Eqns (1) and (2). The net capital stock is then calculated at the mid-year (Eqn (3)), to comply with the SNA 2008 convention.

Net Capital Stock of period t (geometric profile):

$$W_{tB} = \left(1-\frac{\delta}{2}\right)\Big[I_{t-1} + (1-\delta)I_{t-2} + (1-\delta)^2 I_{t-3} + (1-\delta)^3 I_{t-4} + \dots \Big]; \quad (1)$$

$$W_{tE} = \left(1-\frac{\delta}{2}\right)\Big[I_t + (1-\delta)I_{t-1} + (1-\delta)^2 I_{t-2} + (1-\delta)^3 I_{t-3} + (1-\delta)^4 I_{t-4} + \dots \Big]. \quad (2)$$

Average net capital stock of period t expressed in prices of a reference year, *Wt*:

$$W_t = W_{tB} + W_{tE} / 2, \quad (3)$$

where W_{tB} is net capital stock at the beginning of period t; W_{tE} is net capital stock at the end of period t; δ is the depreciation rate; and I_t is investment at the end of period t.

2.2.1. Initial net capital stock

An approach for estimating net capital stock in the benchmark year, which is recommended by various writers (Harberger, 1978; Hulten & Wykoff, 1996; Kamps, 2006; Berlemann & Wesselhöft, 2014), employs the neoclassical growth theory and relies on the assumption that the economy under consideration is in its steady state. As a consequence of this assumption, output grows at the same rate as the capital stock, i.e.:

$$W_{t-1} = I_t / I_g + \delta, \quad (4)$$

where I_t is investment in the initial year; δ is the depreciation rate (geometric depreciation); and l_g is an estimate of the steady-state growth rate of investment in that asset, typically implemented as an average growth rate in the first years of the observation period.

Another method to estimate the initial capital is that which has been used in PWT. Before the version 9.1, the PWT had used a data- driven approach to select the initial capital level, based on the assumptions that the capital-output ratio did not vary systematically by income level, and the same ratio did not systematically change over time (Feenstra et al., 2015). The initial current-cost net capital was set at a level 2.6 times GDP at current prices for each country. More recently, Inklaar et al. (2019) reported on investment data collected for 38 countries across the world, spanning the period before 1950, which, for some countries, go back as far as 1800. They observed that there is a time trend- capital-output ratio increases from, on average, 2.2 in 1950 to 3.5 in 1917, and a large cross-country variation, with 1950 ratios varying between 0.9 and 4. The average capital-output ratio for 1980 is 2.5.

3. An overview of Cape Verde's infrastructure development

Cape Verde is a Sub-Saharan African developing economy, scattered through ten relatively small islands, with 4,033 km^2 and about 560,000 inhabitants in 2022. The country has been experiencing, since its independence in 1975, a remarkable economic performance, as illustrated by its accession to the World Trade Organisation in 2007, becoming its 153rd Member, having also graduated from a low-income economy to the lower-middle income economy status in 2008. Indeed, figures drawn from the *World Development Indicators* (World Bank, 2023a) show that gross national income (GNI) per capita increased from $USD 440 in 1982 to $USD 3,540 in 2022. This strong growth, particularly in the 1990s and 2000s, has resulted in improving living standards of its population, putting the country on track to meet al. the targets of the then Millennium Development Goals (African Development Bank, 2012). However, this transition process has been fraught with difficulties that are characteristic of the middle-income trap (Yülek, 2017). Indeed, Cape Verde's economic development has been showing signs of fatigue since the 2008 global financial crisis. GDP growth fell from an average annual rate of 7.5% in the 2000s to 2.8% in the period 2010–2019 (World Bank, 2023b).

Because of its economic conditions, Cape Verde has always depended upon support and financing from external partners for its development as well as for its main infrastructure development. In 1991, Cape Verde took steps to mobilize financing from international partners to develop its main infrastructure projects and programs. At the time, the Infrastructure and Transport Program (ITP) was in the development phase, with the World Bank playing a preponderant role as a facilitator and one of the country's main multilateral donors. Since then, several infrastructure projects and programs have been developed, financed mainly by international organizations and national development agencies, such as: The World Bank Group (WB), African Development Bank (AfDB), Arab Bank for Economic Development in Africa (BADEA), U.S. Millennium Challenge Corporation (MCC), OPEC Fund for International Development (OFID), Luxembourg Development Cooperation (Lux-Dev), Portugal Development Cooperation (Coop-PT) and China Cooperation (Coop-Ch). Table 2 indicates several of the main infrastructure projects and programs (completed and underway) implemented in Cape Verde since 1993.

It is worth noting that the values of the projects presented in Table 2 do not, generally, include consultancy fees (design and supervision), which constitute, sometimes, a relatively significant share of total project costs in less developed countries (World Bank, 2004). An important feature that emerges from Table 2 is that the aggregate costs of all projects and programs amounts to € 1,222 million. It means that the aggregate costs of infrastructure projects and programmes financed by international organisations, since 1993, constitutes about 67% of the country's GDP in 2019. The financial arrangements for these projects comprised both grants and concessional loans, and various credit agreements between the Government of Cape Verde and international banks. The grants provided by national/international funding agencies for financing the infrastructure projects were usually a component of the financial commitments for each specific project/programme (Table 2). The other components consisted mainly of concessional financing. These programs and projects have allowed the country to develop a set of ports, airports, roads, water supply systems, dams, sanitation systems and electrification systems that have certainly had a positive effect on the country's poverty reduction and economic growth and development (African Development Bank, 2012).

For the road infrastructure sector, the TSRP is the third World Bank-financed project, the goal of which is to support Cape Verde's efforts to improve the efficiency and management of its road assets. The tender process for the rehabilitation of one of the most important roads in Cape Verde, which connects the two main poles of Sal Island, is in its final stage. Turning Cape Verde into a regional technological hub of reference in Africa has been one of the key economic policy strategies of successive administrations, aiming to diversify the economy within and beyond the tourism sector. To this end, the construction works of the Cape Verde Technology Park are in an advanced phase, and the construction of the Mindelo Cruise Terminal is also underway. The Porto Inglês port, besides being a core infrastructure for the Maio Island, will be complementary to the Port of Praia (located in the country's capital), which keeps with the vision of an integrated and sustainable development for the country. As air transport is seen as a crucial sector of the economy, the Government of Cape Verde has recently signed a 40-year Airport Service Concession contract with VINCI Airports, to improve national and international mobility. The obligations of Vinci Airports include a phased-in investment of € 928 million in airport infrastructure.

4. Data and assumptions, and statistical sources

As discussed above, the application of the PIM to estimate construction infrastructure stock require information on the average service lives of different construction infrastructure assets. It is difficult to set up different service lives for each of the assets contained in the heading "other structures" of both SNA 2008 and ESA 2010. For the case of Cape Verde, "other structures" comprise mainly roads, ports, airports, electrical infrastructure, water supply systems,

Table 2. Main infrastructure projects and programmes implemented in Cape Verde (sources: Database (Cape Verde's Ministry of Infrastructure, Territorial Planning and Housing, n.d.), webpages of banks and national/international agencies referenced in Table 2)

Project/Programs	Financing	Cost (€ million)	Start	End
Infrastructure Transport Program (ITP)	WB *#	61.5	1993	2004
Construction of Praia International Airport	AfDB ** ADEA BES	26.2	1998	2005
Extension and Modernization of the Boa Vista Airport	Coop-PT **	17.2	2004	2007
Road Sector Support Project (RSSP)	WB ** BES	25.1	2005	2013
Millennium Challenge Corporation I (Roads, Ports, and, Water)	MCC *	57.4	2005	2010
Coop-PT (Roads, Ports, Airports, Dwelling, Water, and Renewable Energy)	Coop-PT **	600.0	2007	In progress
Recovery and Reform of Electricity Sector (RRSEP)	WB ** BES	39.9	2012	2015
Power Transmission and Distribution System Development Project in Six Islands	JICA ** AfDB	37.4	2013	2018
Millennium Challenge Corporation II (Water, and Sanitation)	MCC *	38.4	2012	2017
Fogo Island Circular Road	PIF ** OFID BADEA	45.6	2010	In progress
Modernization of Praia International Airport	AfDB **	39.2	2013	2018
New Campus of UNICV	Coop-China *	50.8	2017	2021
Transport Sector Reform Project (TSRP)	WB **	8.8	2013	2022
Extension and Modernisation of the Port Inglês	AfDB **	17.2	2019	2022
TechPark Cabo Verde	AfDB **	32	2017	In progress
Requalification, Rehabilitation, and Accessibilities Programs	GOV-CV	100	2018	In progress
Mindelo Cruise Terminal	ORIO-NL * OFID GOV-CV	26.4	2021	In progress

Notes: * – Grant/Grant component; ** – Concessional loans; #- Co-financing: Federal Republic of Germany; Kingdom of the Netherlands; Coop-PT; OFID; BADEA; AfDB.
GOV-CV – Government of Cape Verde; ORIO-NL – The Facility for Infrastructure Development, The Netherlands; JICA – Japan International Cooperation Agency; BES – Banco Espírito Santo, Portugal; PIF – Saudi Arabia Public Investment Fund.

sanitary systems and irrigation infrastructure. Unfortunately, Cape Verde's National Statistical Office does not provide any data on the service lives of fixed assets. An EUROSTAT-OECD report (Eurostat, OECD, n.d.) presents average services lives for fixed assets for a number of countries. For the majority of these countries, the service life of other structures is around 50 years. A study dealing with the capital stock in the NUTS 2 regions (the intermediate level of the geographical division of the economic territory of the European Union) of the then EU-28 (Derbyshire et al., 2013) adopted a service life of 68 years for residential housing, 50 years for civil engineering works and 38 years for other assets. Climate conditions tend to affect the services lives of construction infrastructure, and, thus, it would be reasonable to choose service lives for "other structures" used for other countries with similar climate conditions (tropical climate in the case of Cape Verde). On the other hand, countries differ in their asset composition and depreciation differ across assets (Caselli & Feyrer, 2007) and Cape Verde's infrastructure assets are relatively new, and modern infrastructures tend to be more robust and have service lives longer than older ones. Thus, this study used a service life for other structures equals to 50 years, which is the service life most used for the countries reported in (Eurostat, OECD, n.d.) and in research works dealing with capital stock estimation (Derbyshire et al., 2013). A declining-balance rate (R) of 1.75 was chosen for the aggregate construction infrastructure, which is in the half point in the range from 1.5 to 2 recommended by OECD (2009).

The National Accounts of Cape Verde's National Statistical Office present data on GFCF and GFCF in construction, for the period 1980–2019, that are consistent with the SNA of the United Nations. Three economic series cover the period of analysis. In the "Old Series" of the National Accounts (INE-CV, n.d.a), which is consistent with SNA 1968, construction investment data for the period 1980–2007 are presented in the following disaggregated format: residential housing; non-residential housing; civil engineering works and other construction. Data are presented at both current and constant prices, and the base year is 1980. The first economic series of the "New series" (INE-CV, n.d.b), which is consistent with SNA 2008, presents FBCF data for the period 2007–2015, at current and constant prices, being 2007 the base year. These are disaggregated by: public GFCF; and private GFCF. However, the Use and Supply Tables of the National Accounts (INE-CV, n.d.c), for this period, provide data on GFCF that are disaggregated by the fixed capital in the following sectors: construction; manufacturing; and other sectors. These data are presented at both current and constant prices. The second set of economic series of the "New series" (INE-CV, n.d.d), which is also consistent with SNA 2008, presents data on GFCF, for the period 2015–2019, in a similar format to that of the first set of the "New series", both at current and constant prices, and the year taken as basis is 2015. In addition, data on GFCF, at current and constant prices, are further disaggregated into the following sectors, according to the SNA 2008 convention: construction; manufacturing; ICT; IPP; agriculture and forestry, and other sectors. The accounts of the first economic series of "New series" were retropolated to (few) methodological changes and change in the base year (2015). In these retropolated accounts, GFCF in construction, measured at current prices, are disaggregated into the following segments: buildings; civil engineering; and specialized construction activities. Disaggregate data on construction are not available for the period from 2016 onwards. However, it is recognized that most construction infrastructure works are promoted by government and, in most developing countries, government is practically the sole client for these works. According to the aforementioned economic series, the civil engineering-to-public GFCF ratio, for the period 1980–2015, is, on average, 0.60. For most years, this ratio is in the range from 0.55 to 0.65. Only for four years of this period, this ratio is either just under 0.50 or just over 0.70. Additionally, the share of the fixed capita in the agriculture sector for the period 2016–2019 is, on average, about 10% of total GFCF. Assuming that one quarter of the value of these assets falls in the category of "land improvement", construction infrastructure for the period 1916–1919 was estimated at 62.5% of public GFCF.

A series of procedures were taken to utilize data for civil engineering at 2015 constant prices, for the whole period of analysis. For the period 2007–2019, a great deal of compatibility exists between the economic series 2007–2015 and 2015–2109. In these two series, the values of data on both GFCF and GFCF in construction, measured at current prices, in the year they overlap (2015), are almost similar. As data on civil engineering are not provided at 2015 constant prices, the deflator used for converting data at current prices to data at constant prices is the average of public GFCF deflator and GFCF in construction deflator. The rationale for this approach is that the price evolution of civil engineering works (more capital intensive) is somewhat different from those of the building segment and of GFCF in construction. As civil engineering woks in developing countries are usually the major component of Public GFCF, the price evolution of the former tends to somewhat mirror the price evolution of the latter. Then, data on civil engineering, at current prices, were multiplied by this deflator to convert them to 2015 constant prices.

For the period 1980–2007, the procedure was more complex. The values of data, at current prices, for the year 2007, on both GFCF in construction and civil engineering, are somewhat dissimilar in the economic series 1980–2007 and 2007–2015. Firstly, the data on both GFCG in construction and civil engineering, at 2015 constant prices, were chosen for the year 2007, by following the principle that whenever there is an overlap of data between different datasets, the most recent data are chosen. Then, the factor "value of FBCF in construction for 2007 (at 2015 constant prices) / value of FBCF in construction for 2007 (at 1980 constant prices)" was calculated. Next, this factor was multiplied by the data on GFCF in construction, at 1980 constant prices, to convert them to 2015 constant prices. Finally, data on civil engineering, at 2015 constant prices, were calculated according to the weight of civil engineering in GFCF in construction, as measured at 1980 constant prices.

5. Results and discussion

Before proceeding with the estimation of the construction infrastructure stock throughout the period 1980–2019, it is worth presenting the evolution of construction infrastructure investment spending during the same period. Figure 1 shows the evolution of GFCF in construction infrastructure

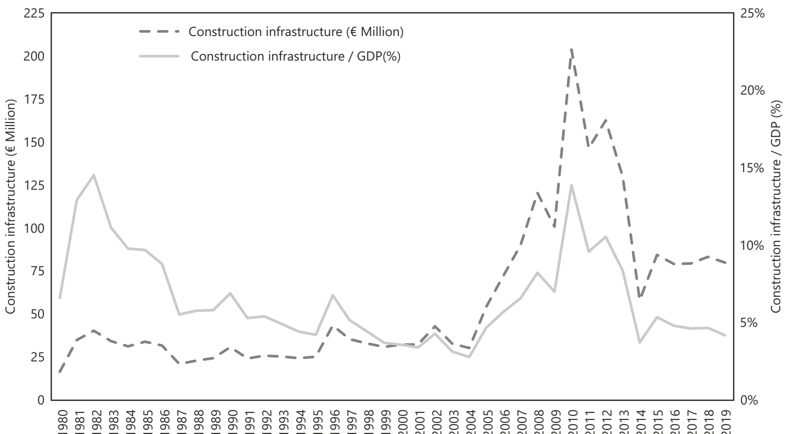

Figure 1. Construction infrastructure investment (2015 constant prices): 1980–2019

in volume terms (for reasons of international comprehensiveness, the values are presented in Euros: (1 € = 110.27 CVE – Cape Verdean Escudos) and the proportion of this indicator in GDP. The figures are presented at 2015 constant prices.

Figure 1 shows that, despite natural annual fluctuations, the evolution of construction infrastructure (in volume terms) in 1980–2019 presented three marked periods: a slight trend of increase in the period 1980–2004; a period of rapid growth from 2004 to 2015; and a period of stagnant growth from 2015 onwards. In terms of the proportion of construction infrastructure in GDP, three evolution patterns are also noticeable: a steady decline in the period 1980-2004; a strikingly increasing growth in the period 2004–2010; and a steady decline from 2010 onwards, with a more pronounced decreasing trend in the period 2010–2015. The rapid growth of infrastructure investment in the period 2004-2015 coincided with the period in which the bulk of infrastructure programmes was implemented in Cape Verde, as can be observed in Table 2.

The decreasing growth of infrastructure investment in the period 1980–2014 (in terms of its share in GDP), despite its increase in volume, is explained by the spectacular growth in GDP in the same period. Particularly noticeable was the GDP growth rate in the period 1995–2007. Indeed, Cape Verde ranked sixth in the top 17 growth performers in Sub-Saharan Africa during the 1995–2007 regional "great take-off" with a real GDP growth rate of 7.2% and real GDP per capita growth of 5.1% for the period (World Bank, 2012). The share of construction infrastructure spending in GDP was, on average, 6.53% in the period of analysis. This figure is very high when seen in an international perspective, particularly when compared with those of other developing countries in SSA. Public investment (which also comprises equipment and other fixed capital) in SSA varied from 7.8% in 1977–1978, a steady decline throughout the 1980s, a stagnation in the 1990s that reached trough of 3% of GDP in 2003, followed by an increase in public investment spending that reached a peak of 5.8% of GDP in 2014. Construction infrastructure investment in Cape Verde constituted about 20% of GFCF in the period 1980–2019 (INE-CV, n.d.a, n.d.b, n.d.d). Thus, GFCF was, on average, about 32.5% of GDP in the same period. Figures drawn from World Development Indicators (World Bank, 2023a) show that GFCF in SSA was, on average, 22.89% of GDP in the period 1982–2021. Total investment (as a percentage of GDP) in Cape Verde in the period 1980–2019 was, on average, even higher than those of the upper-middle income countries in SSA (Botswana, Equatorial Guinea, Gabon, Mauritius, Namibia and South Africa) in the same period.

Turning to the estimation of construction infrastructure stock, the value of the net stock in any year is the sum of net stock in the initial year (1980), net of depreciation, and the net stock calculated according to the Eqns (1), (2), and (3). Recall that the net capital stock in the beginning of the initial year is calculated according to the Eqn (4): I_t = € 13.997 million; δ = 0.035; I_g = 0.077.

The growth rate of I_g that was chosen is that of total GFCF for this indicator is less volatile than investment in construction infrastructure. This growth rate was calculated as the average annual growth rate for the period 1980–1985. The investment I_t was then calculated as the proportion of construction infrastructure in total GFCF in 1980 (0.226). Applying equation (4), W_{t-1} = € 124.929 million. Table 3 presents construction infrastructure net stock and GDP, both at 2015 constant prices, for selected years of the period 1980–2019.

Table 3. Construction infrastructure net stock and GDP for selected years (2015 constant prices)

Year	W*t* (€ million	GDP (€ million)
1980	130.9	250.6
1985	272.0	351.4
1990	357.0	447.1
1995	430.0	597.1
2000	517.0	902.5
2005	617.9	1,158.8
2010	993.6	1,467.9
2015	1,410.4	1,557.2
2019	1,525.4	1,907.2

Table 3 shows that construction infrastructure stock increased continuously in the period of analysis, from € 130.9 million in 1980 to € 1,525.4 million in 2019, an increase of 1.065%. This evolution pattern is consistent, at a worldwide perspective, with the long-term development of total capital stock that has prevailed in the great majority of countries since 1950 (Feenstra et al., 2015). It can also be observed from Table 3 that the growth of GDP in the same period was much lower than that of the infrastructure stock: rising from € 250.6 million in 1980 to € 1,907.2 million in 2019, an increase of 661%. The accumulation of the infrastructure stock was not evenly distributed in the period of analysis. The net stock accumulated in the 16-year period 2000–2015 represented 58.6% of the infrastructure net stock in 2019. To check the robustness of the infrastructure stock estimation at the initial year, a comparison was made between the estimation derived through the steady state model with that proposed by Inklaar et al. (2019). By applying the former method, the contribution of infrastructure stock at the initial year to the infrastructure stock at mid-2019 is 6.55%. By applying the latter method, the total net capital stock at the initial year is 2.5 times 1980 GDP = € 626.575 million. By multiplying this value by 0.226, the value of construction infrastructure stock at the initial year is € 141.606 million. Thus, the contribution of infrastructure stock at the initial year to the infrastructure stock at mid-2019 is 7.44%. A study dealing with public capital stock statistics (that is, public investment corrected for fixed capital consumption) for 22 Organisation for Economic Co-operation and Development (OECD) countries, for the period 1960–2000 by Kamps (2006) reported that the contribution of the public net capital stock in the period before 1960 is 7.9% of the public capital stock at the beginning of the final year, and that this contribution is less than 10% for all countries of the sample. Thus, our estimation of the construction infrastructure stock at the beginning of 1980 is robust and the importance of the initial capital stock to the level of capital stock series fades over time.

Figure 2 shows the evolution of the construction infrastructure net stock-to-GDP ratio for the entire period 1980–2019. Again, these indicators are measured at 2015 constant prices.

The evolution depicted in Figure 2 shows four clearly marked periods: a rapidly rising trend throughout the 1980s that reached a peak of 84% of GDP in 1987; a steady decline in the 1990s and first half of 2000s that reached a trough of 52% of GDP in 2006; a rising trend in 2006–2015 that reached a peak of 89.4% in 2015, the highest value of construction infrastructure net stock as a percentage of GDP; and a trend of decline from 2015 onwards, reaching 80% of GDP in 2019. It would be worthy of note comparing Cape Verde's construction infrastructure net stock with those of other middle-income countries, particularly in SSA. The authors of this study are not aware of any published study dealing with this capital stock statistics, in a separate format, as far as developing countries are concerned. However, the results reported in Kamps (2006) might provide some useful insights. Kamps (2006) reported that, in most of the OECD countries (including Greece, Portugal and Spain, which had become members of the then European Community in the 1980s), government net capital stock as a percentage of GDP increased from 1960 to the 1980s and then started to generally decline thereafter. Government net capital stock in the OECD countries declined, on average, from 57.8% of GDP in 1980 to 55.3% of GDP in 1990 and to 51.4% of GDP in 2000. Out of the 22 countries, only Japan and New Zealand had a government net capital stock higher than 77% of GDP in the period 1990–2000. This trend in the most advanced economies of the world does not appear to be changing: a slight trend of decline can be observed in the total capital-output ratio of high-income countries and highest performer middle-income countries in the period from 2000 onwards. Indeed, neo-classic growth theory implies that the returns of capital diminish at a rate which depends upon the amount of capital already put in place (Aghion & Howitt, 1999, cited in Derbyshire et al., 2013). Construction infrastructure net stock for Cape Verde was, on average, 70.9% of GDP in the period 1980–2019. It can also be inferred from a close observation from Figures 1 and 2 as well as from Table 3 that the decline in the construction infrastructure net stock-to-GDP ratio in the period from around 1995 to 2006 is explained by the spectacular growth in GDP rather than a decline in infrastructure spending. It is worth noting that construction infrastructure stock does not equate government capital stock for some of the physical infrastructure, particularly in high-income countries, is promoted by the private sector, and government capital stocks also comprises fixed capital assets other than structures. The net capital stock of buildings and other structures varies between 80% to 90% of the total net capital stock (Feenstra et al., 2015) as the depreciation rates of the former are much lower than those of other fixed capital assets.

Thus, the general picture is that Cape Verde, as a newcomer in the development process, has already reached a level of construction infrastructure net stock-to-GDP ratio that is more prevalent in most industrially advanced economies. The high value of the ratio may, partly, be explained by the country's geographic characteristics. Geographic segmentation and a low population density necessitate duplication of infrastructure facilities (African Development Bank, 2012). For example, Cape Verde has four international airports, one of them (in Boa Vista Islands) is practically aimed at international tourism services. The country also took advantage of favorable conditions of external financing (mainly grants and loans at concessional terms) in the process of graduation to the lower-middle income status to upgrade its infrastructure in transport, water and sanitation, and irrigation sectors (African Development Bank, 2012). On the other hand, Cape Verde' economy is heavily dependent on tourism (25% of GDP in 2019), remittances and foreign direct investment (World Bank, 2023b), which are extremely vulnerable to external

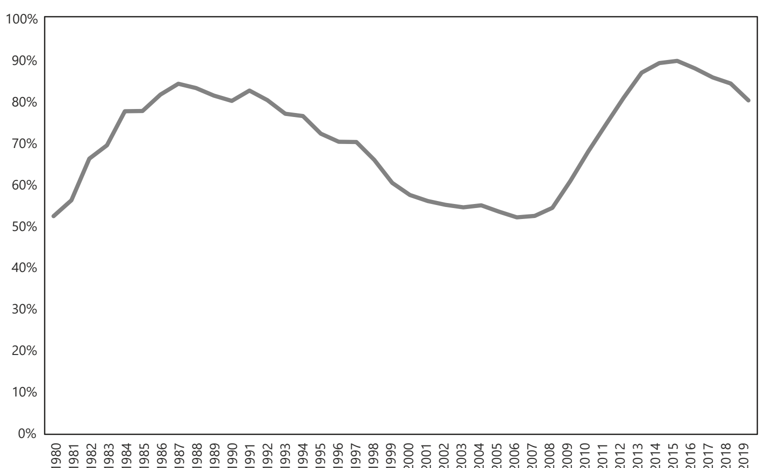

Figure 2. Construction Infrastructure Net Stock-to-GDP Ratio (2015 constant prices): 1980–2019

shocks. Furthermore, official development assistance to the country has declined from 18.7% of GDP in 2010 to 8.6% of GDP in 2021. Of course, every country should aspire to attain the sustainable development goas (SDGs) to the benefit of all its residents. In some cases, meeting these goals will require an adequate level of infrastructure. Of particular interests are SDG 6 "Ensure availability and sustainable management of water and sanitation for all"; and SDG 7.1 "Ensure access to affordable, reliable, sustainable and modern energy for all". As referred to earlier, a central question is the level of infrastructure stock needed for an efficient functioning of the economy. Global Infrastructure Hub (2018) reported the estimated infrastructure stocks per person for 10 "Compact with Africa" (CWA) countries participating in the Group of 20's (G 20) Initiative. These countries comprise both low-and lower-middle income economies. The infrastructure stock intensity in 2015, for the lower-middle income countries, varied from about US$ 500 for Ghana, Senegal and Cote d'Ivoire to about US$ 1,750 for Morocco (2015 prices and exchange rates). The higher infrastructure per person for 2040 corresponding to the 'relative investment need' is that for Morocco – about US$ 3,700 (2015 prices and exchange rates). In 2015, Cape Verde had 522,800 inhabitants (INE-CV, 2016) and the average exchange rate $US/€, for the same year, was 0.9015. As can be observed in Table 3, the construction infrastructure net stock for Cape Verde, in 2015, is € million 1,557.2. Thus, construction infrastructure net stock per person for Cape Verde, in 2015, is US$ 3,291 (2015 prices). As Cape Verde is well positioned to attain the key infrastructure development-linked targets of the SDGs (INE-CV, 2016), it is reasonable to suggest that the planning and prioritisation of new infrastructure projects should be based on their economic efficiency as well as on their environmental and social impacts.

6. Conclusions

This paper provides estimates of the construction infrastructure net stock for Cape Verde for the period 1980–2019, and discusses methodologic issues regarding the measures of infrastructure investment for producing construction infrastructure stock statistics. One advantage of the set of investment data for producing this capital stock statistics is that it was drawn from the same source (Cape Verde's National Statistics Office), and has been compiled according to the SNA 2008's definition of "other structures".

The construction infrastructure stock estimates reveal that the evolution of construction infrastructure stock-to-GDP ratio presents four marked periods: a rapidly rising trend throughout the 1980s that reached a peak in 1987; a steady decline in the 1990s and first half of 2000s that reached a trough in 2006; a rising trend in 2006–2015 that reached a peak of 89.4% in 2015, the highest value of construction infrastructure net stock as a percentage of GDP; and a trend of decline from 2015 onwards. The results further show that the decline in the ratio throughout 1990s and first half of 2000s is explained by the spectacular GDP growth in this period rather than a decrease in infrastructure investment. Based on the results of government net stock for 22 OECD countries for the period 1960–2000, the results of the study also reveal that construction infrastructure net stock-to-GDP ratio for Cape Verde has reached a level that is more prevalent in most advanced economies. The high value of this ratio suggests that the country should shift its focus from building new infrastructure projects to managing the considerable amount of infrastructure stock.

The role of infrastructure in the development process, particularly in least developed countries, has been meriting a special attention from the part of national bodies and international development agencies. As pointed out by L. Ruddock and S. Ruddock (2019), whether infrastructure financing comes from private or public funding, good infrastructure will continue to be a prerequisite for economic and social development in developing countries. However, what matters most is not the amount of infrastructure per se, but the quality of services rendered by the infrastructures (Hulten, 1996). Thus, the knowledge of reliable data and measurement of a country's infrastructure net stock are a crucial element for the long-term management of these assets.

The main contribution of the study comes from the use of different data sets drawn from Cape Verde's National Statistical Office to present infrastructure investment data in a comprehensive way, more suitable for comparative studies. A great deal of effort was made to reconcile different material to fill missing data. Additionally, contrary to other individual studies dealing with built capital stock estimation, this study presents construction infrastructure stock statistics in a separate format. This subset of capital stock is more suitable for the assessment of public capital productivity.

The results of the study shed new light on the assumption that the level of infrastructure stock, and to a certain extent the level of the built capital stock, captures some of the dimensions of a country's level of urbanization and industrial structure (Lopes, 2022). The level of infrastructure stock might constitute an important variable in construction industry activity modeling. Further studies on infrastructure stock estimation for individual countries in different stages of economic development would provide a more comprehensive picture of the relationship between infrastructure investment and economic growth and development. The scope of the study coull be extended to include a separate estimation of the other subset of government net stock (machinery, transport equiment and ICT).

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Author contributions

JL conceived the study and was responsible for the design and development of the data analysis. JL and AT were responsible for data collection and analysis. JL and AT were responsible for data interpretation. JL was responsible for data validation. JL and AT wrote the first draft of the article. JL was responsible for the review and editing of the article. All authors have read and agreed to the published version of the manuscript.

Disclosure statement

The authors declare no conflict of interest.

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