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Abstract

The Cyprus Statistical Service (Cystat) computes annual data for the net capital stock and capital depreciation by NACE Rev. 2 classification using the Perpetual Inventory Method (PIM). This data is available with a two-year lag, whilst quarterly data, including a breakdown by institutional sector, is not produced. On the basis of the latest vintage of annual data, this paper provides a quarterly breakdown of net capital stock for the total economy and its depreciation for the period 1995-2015 in constant 2005 prices. We further present a quarterly breakdown by institutional sector, namely public, housing and other private sector.

Keywords: Capital stock, consumption of fixed capital, gross fixed capital formation, perpetual inventory method.

JEL Classification: C82, E22, H54, R53.

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Estimates of Public, Housing and Other Private Sectors' Net Capital Stocks for the Cyprus Economy: 1995Q1-2015Q4

Introduction

Capital stock in an economy is defined as the total value of fixed assets at a given point in time and in a given area. More specifically, according to Nehru and Dhareshwar (1993), the term "capital" refers to goods that are fixed, tangible, durable and reproducible. Since the introduction of the Solow-Swan exogenous growth model in 1956, the importance of capital stock estimates has been continuously enhanced.

Specifically, many researchers have utilised capital stock estimates in various circumstances and in ways which emphasise its strong relation to economic policy. Perhaps the most famous use of capital stock estimates has been for the examination of the premise that public capital "crowds out" private capital (Aschauer, 1989a,b; Baltagi and Pinnoi, 1995; Kamps, 2004; Arslanalp *et al*, 2010; Marrocu, 2010. For a survey, see Bom and Ligthart, 2014). Other common uses of capital stock estimates include the estimation of production functions (Puig-Junoy, 2001, Bloom *et al* 2004), the estimation of total factor productivity (Fedderke and Bogetić, 2009; Sharma *et al*, 2007) and growth accounting (Barro, 1999; Crafts, 2004).

The use of capital stock estimates has not been confined to measuring growth and productivity but has also spread to other aspects of economic policy. For example, Hodrick and Prescott (1997) have employed the capital stock to assist them in their empirical investigation of US business cycles, while Desai *et al* (2005), have utilised capital stock estimates to investigate the extent to which foreign capital spending affects

domestic capital spending. In addition, King and Levine (1993) also employ capital stock estimates to examine their relation with financial development and test the premise that the latter is essential for economic growth and development.

However, despite its wide use in aspects related to economic policy, the availability of capital stock estimates remains limited. While the OECD database remains the primary source of capital stock data for researchers, the obvious drawback is the lack of a data series for countries which are not members of the OECD. In addition, the complexity associated with the derivation of capital stock quarterly estimates and the differences in national assumptions makes these difficult for the purpose of international comparisons.[1] Consequently, the derivation of quarterly estimates of the capital stock is a task which should be addressed by individual countries.

In Cyprus, the Cyprus Statistical Service (Cystat) has been using the Perpetual Inventory Method to compute annual data for the net capital stock and consumption of fixed capital, in line with Eurostat directives.[2] Nevertheless, and again according to Eurostat's ESA 2010 Transmission Programme[3], this data is only available with a two-year lag. Additionally, official quarterly data for the capital stock and consumption of fixed

[1] The interested reader can refer to see Schreyer *et al* (2011) for more details.

[2] The stock of capital can be measured in two ways: (i) by direct observation (survey-based or other sources) of fixed assets or (ii) by using the Perpetual Inventory Method (PIM). As described in the next section, PIM is a method which enables the capital stock to be estimated based on historical investment series, the average service life of fixed assets and survival functions, with the latter capturing the variability of service lives across each type of fixed asset. As direct observation of the fixed assets is extremely time-consuming as well as expensive, PIM is the most commonly used method. Some drawbacks of the PIM model approach should be noted, i.e. capital stock estimates based on PIM are subject to considerable error if investment data and service lives assumptions of fixed assets used are not accurate. According to Young and Musgrave (1980), there is a need for estimates based on direct measurement to supplement and serve as a check on the perpetual inventory estimates. Nevertheless, the aforementioned authors note that even in the US, limited use has been made of direct measurement because the existing data are incomplete and because there are problems in the valuation of the assets in stock as extending the coverage and obtaining the information needed to assign the desired valuation to assets would require a substantial statistical programme.

[3] Regulation (EU) No 549/2013 of the European Parliament and of the Council of 21 May 2013 on the European system of national and regional accounts in the European Union.

capital for Cyprus, which are necessary for economic analyses, is not produced by Cystat.

To cover this gap in the existing data coverage, this paper utilises the annual estimates for the depreciation and evolution of the stock of capital from Cystat to provide estimates of: (i) quarterly data for the net capital stock and consumption of fixed capital for the period 1995-2013 (ii) the total economy net capital stock and consumption of fixed capital (in constant 2005 prices) quarterly breakdown for the years 2014 to 2015 by incorporating the publicly available investment series in the law of motion of capital, and (iii) a breakdown of the quarterly data by institutional sector, namely public, housing and other private sector (i.e. excluding housing).

The remainder of this paper is organised as follows: Section 2 briefly discusses the Cystat approach in estimating the capital stock and depreciation data using the PIM model, Section 3 describes the available data and the estimation methodology, Section 4 presents the constructed data and Section 5 concludes.

2. The Cystat approach

In order to estimate the capital stock data according to the PIM model, Cystat requires three basic ingredients: a long time series of investment data, information on the average service lives of fixed assets and an associated survival function (Cyprus GNI inventory, 2011).

Regarding the investment series, the PIM model requires these to be as long as the average lifetime of capital goods. A long time series is available from Cystat (albeit not publicly available) and dates back to 1960 for the main asset categories, namely construction, machinery and transport according to economic branch (i.e. the

International Standard Industrial Classification (ISIC) classification). Using conversion keys from ISIC to NACE, the old figures covering the period 1960-1980 (9 branches) were reclassified into the present form of 21 branches as per NACE Rev. 2. Data as from 1980 have been compiled on the basis of the NACE classification. The data for the categories of machinery and transport was expanded up to the year 1950, with effort devoted to extending the series for construction. More recently, the aforementioned three main asset groups were expanded to include new sub-categories, e.g. computers, software, etc.

To distinguish between the values of capital which are currently available in the economy, as compared to the values of the stock of capital as originally purchased, the net and gross capital stock concepts are utilised. Specifically, the latter refers to the value of all fixed assets in the economy while the former (net capital stock) is the gross capital stock less the cumulative value of consumption of fixed capital (i.e. depreciation) at the given moment in time.[4]

Finally, to convert the investment time series from current (historical) to current replacement prices,[5] various price indices were used as inflators, e.g. prices of various inputs, Laspeyres prices indices, etc. Since the original data series were recorded at different base years, a linking process has been undertaken to chain the whole period together.[6] In order to make capital stock estimates in line with output, 2005 was chosen as the reference year.

[4] Slight differences between the two reflect capital which has been retired.

[5] The terms "current and constant replacement costs" are used to refer to current and constant prices.

[6] While both approaches reflect the values at which the fixed assets are to be added together, the difference between current and constant replacement costs deserves a mention here. In contrast to the real GDP estimation where the value of its components reflects their price during a specific point in time, the capital stock includes assets which were purchased or created in different points in time. As such, an adjustment process is necessary so that all asset values are comparable. From this process, the current replacement

In addition to the historical investment series, PIM also uses the average service lives of fixed assets. In principle, a prior knowledge of the age composition of fixed assets provides useful information for capital stock calculations, since it can be used in the establishment of the technically correct expected lifetime for those assets. In order to obtain such knowledge, it is necessary to either make ad-hoc surveys on specific types of capital equipment or to collect technical information on their behaviour. Table 1 below provides information on the service lives assumed by Cystat in the PIM model by type of asset.

Table 1: Service lives for fixed assets used by Cystat

Fixed Asset	Average Life (years)
Dwellings	75
Roads	55
Non-residential Buildings	60-75
Other civil engineering	75
Machinery	10-19
Computers	5
Motor vehicles	10
Airplanes	25
Ships	18
Plantations	24
Intangible assets	9-36

Although the average service life of fixed assets is an important parameter of the PIM model, it provides little information if the dispersion around the average is not known. In order to characterise this dispersion, a bell-shaped probability density function is often assumed, indicating which part of the investment realised previously has been discarded during a specific period (hence the name survival function). For the purposes of Cystat's estimations, the log-normal function, as recommended by Eurostat, is used.

cost refers to the current market value of the assets. The constant replacement cost is the current market value deflated/inflated to the reference year.

The estimation procedure is as follows: the gross capital stock is first estimated using the investment series and the assumptions regarding the average service life and survival function. To estimate the net capital stock, the depreciation function of fixed assets is introduced in the PIM model. Cystat calculates consumption of fixed capital using the straight line method, which assumes that the value of the fixed assets is written off at a constant rate over its service life.

One issue that needs to be noted is that, as a result of the Turkish invasion in 1974, an enormous amount of capital stock was either destroyed or is still inaccessible. This needs to be taken into account and, as such, estimates on the approximate level of losses of capital assets in each economic branch were derived from official reports of that period as well as other academic sources. These were then deducted from the corresponding capital stock in the year 1974, for all categories in each economic branch. On the remaining capital stock, the annual investment was added. In other words, the capital stock from the year 1975 onwards that results from the PIM model is "corrected" from the invasion effects (and thus termed "net of invasion losses"). The Cystat annual data for the net capital stock and capital depreciation net of invasion losses in 2005 prices is available in the online appendix accompanying this paper.

3. Data and Methodology

3.1. Data

An important component in preparing the capital stock estimates by institutional sector is the availability of investment series by institutional sector. In particular, category "P4-Construction: Housing" from the "Gross Fixed Capital Formation by Investment Product" Tables published within the context of the quarterly National Accounts releases is used for the production of the housing net capital stock and its associated

depreciation.[7] For the public sector, the general government gross fixed capital formation available from the quarterly Fiscal Accounts releases is used. The other private sector (i.e. excluding housing) gross fixed capital formation series can be then estimated as a residual.

For the estimation of the quarterly depreciation, the annual depreciation rates are calculated using capital depreciation in levels applied to the previous year's net capital stock. On the basis of the annual rate, a quarterly profile is constructed and smoothed in order to estimate the quarterly level of capital depreciation.

Finally, given the availability of net capital stock and depreciation data by NACE Rev. 2 classification, and using the 1995-2013 available data on gross fixed capital formation which are incorporated in Cystat's PIM model, the definition of the public sector used in this paper comprises of a combination of the NACE Rev. 2 sectors O (public administration and defence; compulsory social security), P (education) and Q (human health and social work activities).

3.2. Methodology

This section describes the methodological approach taken, which comprises of three steps: first, annual estimates for the 2014 and 2015 total economy net capital stock and capital depreciation are produced; second, quarterly estimates for the period 1995-2015 relating to the total economy dimension are prepared; and third, quarterly estimates by institutional sector are constructed.

[7] Non-seasonally adjusted data were employed as they better reflect the state of the economy at each point in time. The researcher should therefore seasonally adjust the data before any econometric estimation.

To estimate the total economy net capital stock and consumption of fixed capital (in constant 2005 prices) for the years 2014 to 2015, this paper utilised the publicly available investment series and assumed that the depreciation rate is constant at the rate observed in 2013. The law of motion of capital is utilised such that:

$$K_{t+1} = K_t + I_t - \delta K_t$$

Where K_t refers to capital at period *t*, I_t is investment at period *t* and δ denotes the depreciation rate.

Annual estimates are also produced for each institutional sector (i.e. public, housing and other private sectors) separately, with the annual estimates for the other private sector (excluding housing) produced on the basis of a residual calculation. The aforementioned data is incorporated in the law of motion of capital for each sector separately. Note that the rate of depreciation depends on the previous year's net capital stock.

To estimate the quarterly data for the total economy net capital stock and consumption of fixed capital for the period 1995-2015, an estimate needs to be made regarding the level of the capital stock for end-1994, on the basis of the capital data available from 1990 in ESA 1995. In particular, the 1994 growth rate as per ESA 2010 figures is constructed by adjusting for the difference observed in the 1995 growth rate across the ESA1995 and ESA 2010 data and then applied to the 1995 net capital stock.

Using the annual data for the level of depreciation and the level of the net capital stock of the previous year, the annual depreciation rate is calculated. Subsequently, a quarterly growth rate is estimated on the basis of geometric growth rates, which is then smoothed

utilising a declining share of the previous year's quarterly rates.[8] Using the quarterly growth rate, a quarterly series of consumption of fixed capital is generated. Finally, a quarterly series of the net capital stock is produced on the basis of the law of motion of capital up to the third quarter of each year. Finally, for the fourth quarter of the year, the annual figure for the net capital stock is used given that this relates to the stock at the end of the year.

For the intra-annual profile to be more precise, the annual retirement of the net capital stock is also taken into account (i.e. the difference between the addition to the capital stock, i.e. the investment for the year in question, less the decline in the value of the capital stock, i.e. the level of capital depreciation). Given the lack of available data for 2014 and 2015, the annual retirement in each year is assumed to equal to the average observed over 1996-2012.[9]

To estimate the quarterly data for each institutional sector separately, a similar approach to that followed for the total economy net capital stock and capital depreciation is pursuit. To construct the initial capital stock, assumptions are made given the availability of net capital stock and depreciation data by NACE Rev. 2 classification. In particular, using the 1995-2013 available data on gross fixed capital formation which are incorporated in Cystat's PIM model, the public sector comprises of 100% of NACE Rev. 2 sector O (public administration and defence; compulsory social security), 83%

[8] The previous year's depreciation rate was employed in order to safeguard the smoothness of the data across time and avoid sharp increases and decreases as well as strong seasonality patterns in the series due to changes in the depreciation rate. Obviously this smoothness adjustment comes at the cost of having a slightly different depreciation rate than the observed. As such, a trade-off between smoothness and accuracy can be expected in the data. After many shares have been tested the one used is that in q1 the depreciation rate is the average of the current and the past years' rate, q2 is 2/3 current year and 1/3 past year, q3 is 3/4 current year and 1/4 past year and q4 is the current year's depreciation rate. The rationale behind the choice of this specification is that it minimises the trade-off between smoothness and accuracy.
[9] 1995 and 2003 were outlier years in retirement of capital and were thus excluded.

of NACE Rev. 2 sector P (education) and 22% of NACE Rev. 2 sector Q (human health and social work activities). The housing sector net capital stock and depreciation is separately reported by Cystat in addition to the data across the 21 branches. As noted previously, the other private sector component is estimated as a residual calculation.

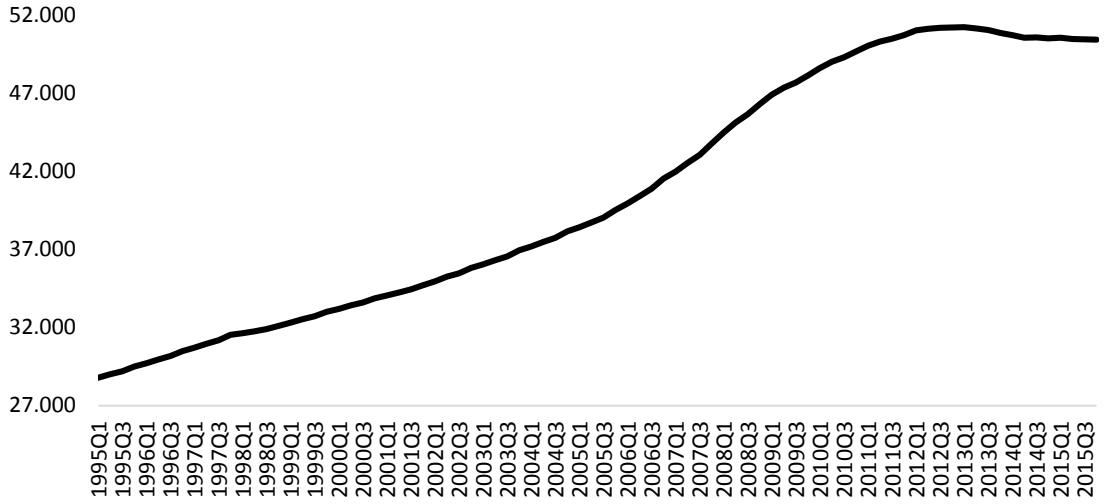
4. Estimates

This section presents the quarterly estimates of the net capital stock and capital depreciation for the total economy and for each institutional sector separately. This dataset is available in the online appendix accompanying this paper.

The quarterly estimates for the total economy net capital stock, presented in Figure 1, demonstrate an upward trend until 2013Q2 followed by relatively small year-on-year declines since then. These declines can be attributed to the significant contraction in investment in the years after 2013.[10] Note that the year-on-year growth rate of the net capital stock accelerated during the 2006-2012 period, something related both to the accession of Cyprus into the EU in May 2004 and the real estate boom experienced during those years. Specifically, the peak of the capital growth rates can be found in mid-2008, at the height of the real estate and construction boom.

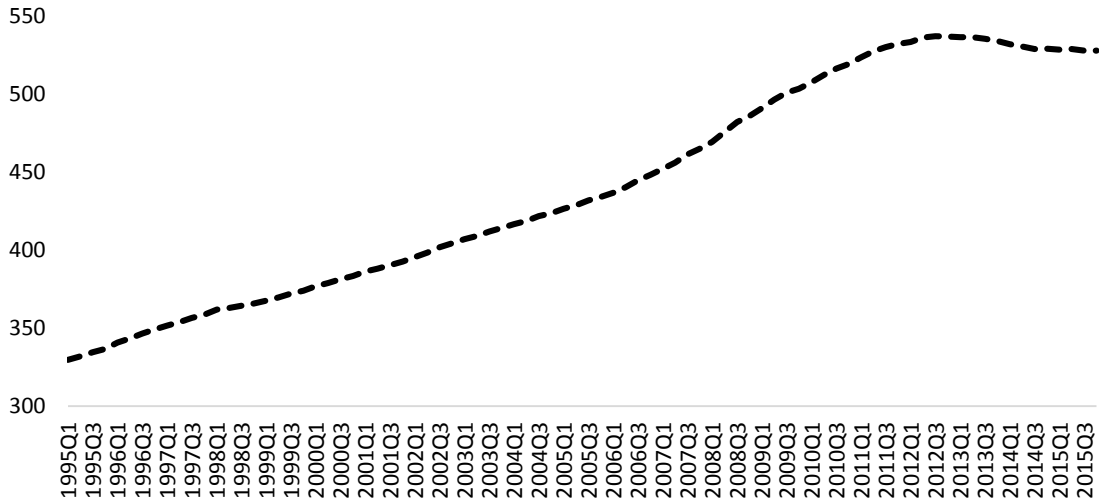
[10] It should also be noted that data for 2014 and 2015 are subject to changes given the September revisions in recent historical National Accounts data.

Figure 1: Total Economy Net Capital Stock (€ million)



A deceleration is observed after mid-2008, mostly due to the 2009 recession, the first since the Turkish invasion in 1974, as well as the waning-off of the construction boom and the destruction of the main electricity producing plant in July 2011. The total economy capital depreciation developments, in Figure 2, follow a similar path.

Figure 2: Total Economy Depreciation (€ million)



Moving the focus to the public sector net capital stock (Figure 3), a more volatile path of the year-on-year growth rate is observed. A peak is reached in 2013, in accordance with increased public investment expenditure until 2011, followed by a decline in its

level since then. Regarding capital depreciation (Figure 4), an acceleration in the relevant rate is observed as of early 2010, possibly attributable to the depreciation of military equipment purchased in previous years.[11]

Figure 3: Public Sector Net Capital Stock (€ million)

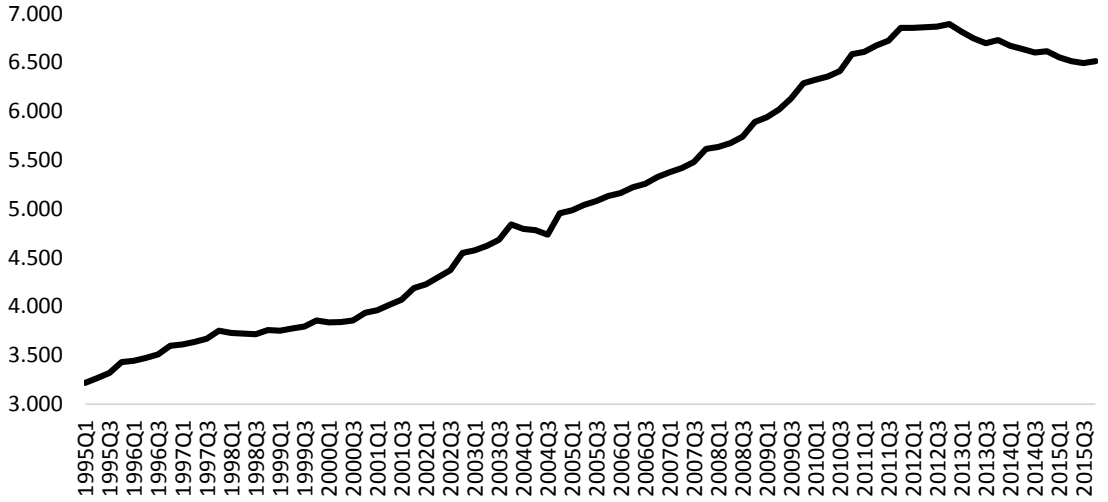
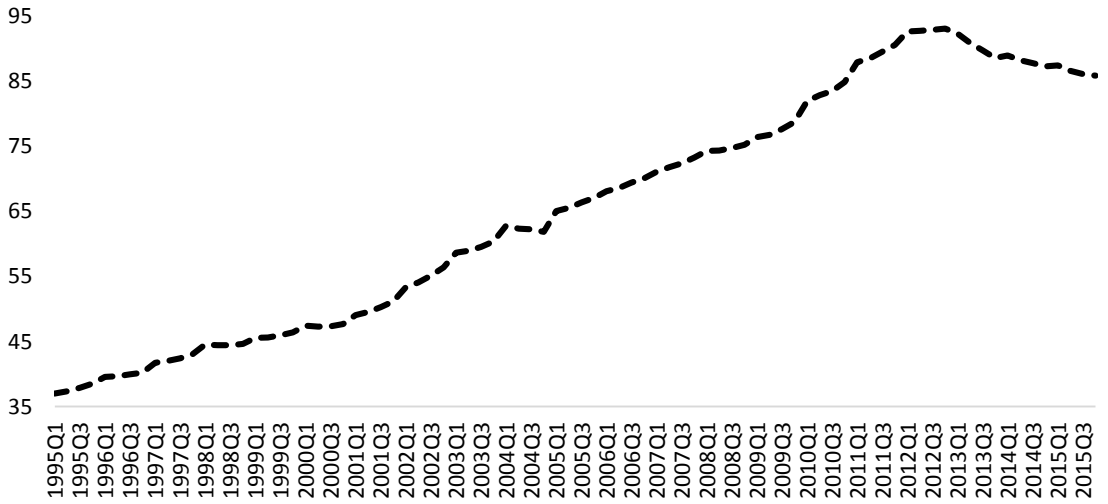


Figure 4: Public Sector Depreciation (€ million)



Turning to the housing sector net capital stock (Figure 5), positive year-on-year growth rates are observed until mid-2014, turning negative only since then. The much smoother growth rate observed relative to the public sector net capital stock might be attributable

[11] It should be noted that ESA 2010 recognises that military expenditure has the nature of investment given its productive potential for the external security of a country, over several years.

to the nature of residential investment, which has the highest average service life among all types of assets (75 years, see Table 1, p. 8). As a consequence the housing stock has the smallest consumption of capital each year. This view is supported by the smooth profile of the housing sector capital depreciation.

Figure 5: Housing Sector Net Capital Stock (€ million)

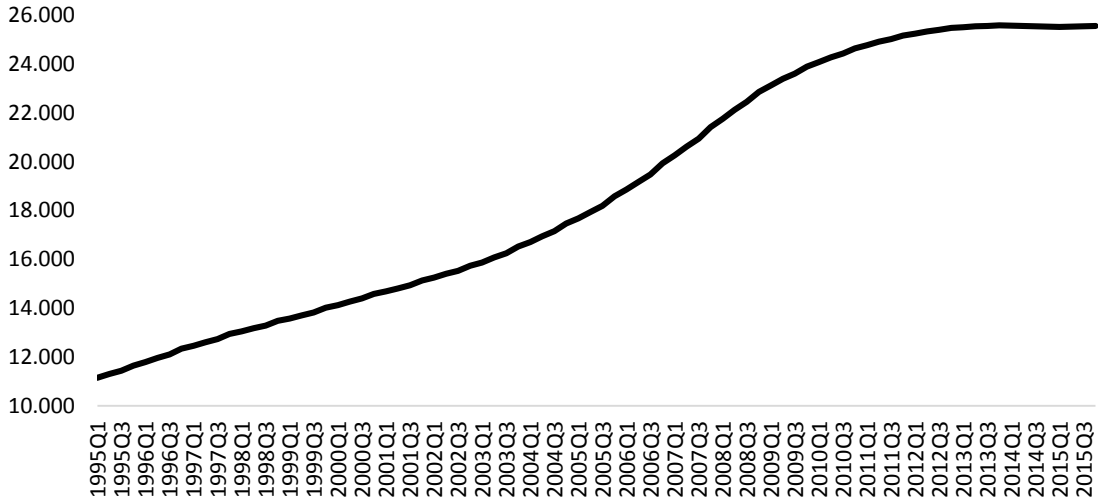
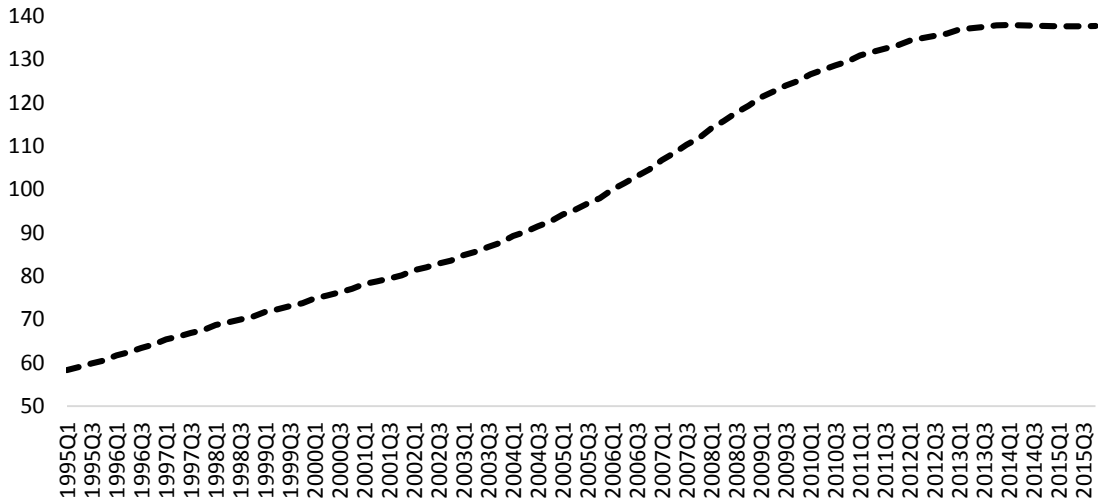


Figure 6: Housing Sector Depreciation (€ million)



The remaining two figures demonstrate the estimations for the other private sector net capital stock (Figure 7) and its capital depreciation (Figure 8). Given that, as already discussed, these are estimated as a residual calculation after subtracting the public and

housing sector dimensions from the total economy net capital stock and capital depreciation, respectively, it is not surprising to observe a somewhat more volatile quarterly pattern.

Figure 7: Other Private Sector Net Capital Stock (€ million)

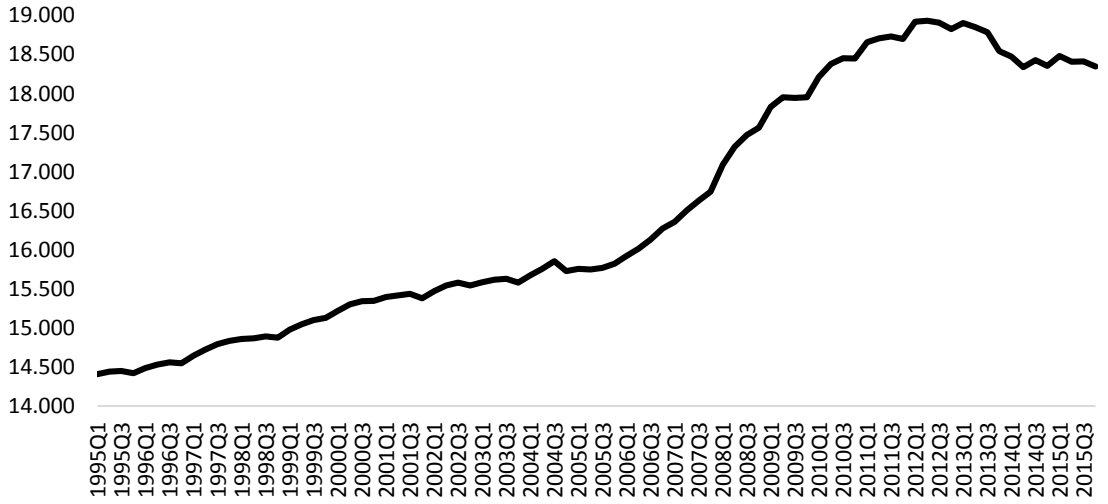
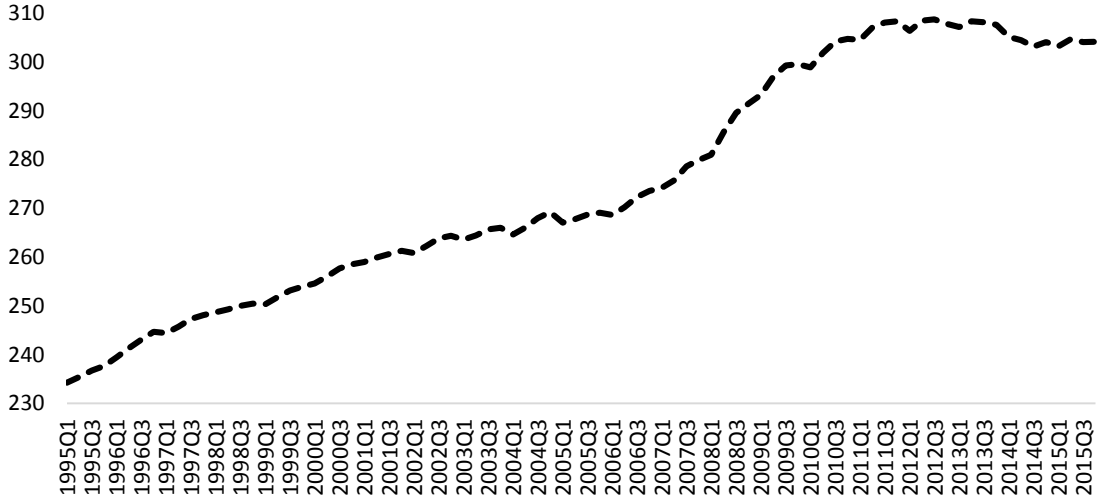


Figure 8: Other Private Sector Depreciation (€ million)



As a share of the total economy net capital stock, the public sector component exhibited a small increase of about 2 percentage points over the period 1995-2015 (to about 13%). The most significant shift of shares was observed in the other private sector component, whose share is estimated to stand at about 36% in 2015, at a loss of about 14 percentage

points since 1995. Of this decrease, 12 percentage points were captured by the housing sector, to roughly 51% in 2015 compared to 39% in 1995, while the remaining 2 percentage points were captured by the public sector component as previously suggested. These large changes in the composition of the capital stock are reflective of Cyprus's past economic performance, with an emphasis on housing and real estate developments, in contrast to other private sector capital formation.

5. Conclusions

To the best of the authors' knowledge, this paper is the first to provide quarterly estimates of the net capital stock and capital depreciation for the Cyprus economy relating to the period 1995-2015 in constant 2005 prices It is also the first to provide a quarterly series of net capital stock and depreciation by institutional sector, in particular public, housing and other private (excluding housing). Both contributions allow researchers to use this new dataset for a variety of purposes, while the second allows researchers to view Cyprus' past economic performance through the lens of changes in the composition of the capital stock.

The breakdown of the capital stock series has three features which both facilitate its use and make its estimation more accurate: First, it is based on a simple application of the capital evolution equation. Second, it is based on investment data (i.e. gross fixed capital formation) available on a quarterly frequency by Cystat, which conform to the ESA 2010 methodology and are publicly available. Third, it takes into account the observed depreciation rates on account of the annual statistics of the net capital stock and level of depreciation.

Overall, we expect that the quarterly capital stock data will prove useful for applied research on the macroeconomic effects of different categories of capital.

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