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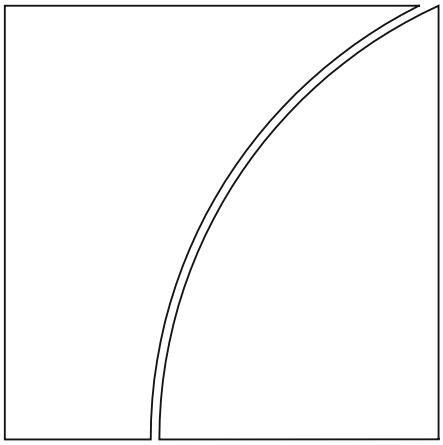

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Enhancing Euro Area Capital Stock Estimates

by Zlatina Balabanova and Ruben van der Helm

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Enhancing Euro Area Capital Stock Estimates

Zlatina Balabanova,[1] Ruben van der Helm[2]

Abstract

Official euro area wide statistics on capital stock and its breakdowns by asset types and sectors are not yet available, but very useful for economic and financial stability analysis. This paper proposes a constrained optimization model with the help of which a full cross-sector classification of capital stock by non-financial asset type is estimated. The model is applied for the estimation of capital stock by institutional sector, including households' housing stock and households' housing wealth both for the euro area and euro area Member States currently not estimating and/or publishing such data.

Keywords: Capital stock, household housing wealth, perpetual inventory method, constrained optimization, euro area, institutional sector

JEL classification: C33, C82, E02, E22

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The views expressed are those of the authors and do not necessarily reflect those of the European Central Bank and De Nederlandsche Bank.

1. Introduction

This paper proposes a constrained optimization model with the help of which a full cross-sector classification of capital stock can be estimated. The model is applied for the estimation of capital stock by institutional sector, including households' non-financial asset types and households' housing wealth both for the euro area and euro area Member States (Monetary Union Member States (MUMS)) currently not estimating and/or publishing such data.

As a follow-up on the recent financial crisis there have been numerous actions to strengthen data collection. More detailed and complete financial and economic data would give policy makers a broader view on the structure of the economy. Such data is needed in order to understand the relations between the different institutional sectors in the economy. More detailed sector data would give information that could identify early enough the vulnerability of the different domestic sector to external shocks.

There are many requests for more detailed data collection. For example in April 2009, G-20 requested the Financial Stability Board (FSB) and International Monetary Fund (IMF) to pin point data gaps and to suggest an improvement on data collection. The respond of the FSB and the IMF included 20 recommendations in total and one of them tackled the subject of better sector breakdown of economic data. The commission on the measurement of economic performance and social progress (Stiglitz et al., 2009) included in its report a recommendation that was directly addressing the sector compilation of balance sheets including non-financial assets. In August 2010 the Bank for International Settlements (BIS) organised a special conference on initiatives to address data gaps revealed by the financial crisis.

The compilation of the euro area balance sheets for non-financial assets by institutional sector is challenging since most of the MUMS don't provide detailed sector breakdowns for the different asset types. Since end-2009 quarterly euro area non-financial assets (gross and net) are compiled for the total economy by asset type and for the total fixed assets by institutional sectors. At present there is no compilation of the different non-financial asset into institutional sectors.

The theory underlying capital stock measurement was introduced in the 1960s by Jorgenson (1963). Later on Hall and Jorgenson (1967) worked on the estimation of cost of capital. Jorgenson and Griliches (1967) and Jorgenson and Christensen (1969) modelled a measure of capital using service prices. After the 1960s a large number of economists worked on capital theory (see Jorgenson (1969), Hulten (1990), Diewert et al. (2006)).

In addition to the academic research done in this field, central banks and statistical institutes worldwide work on estimating non-financial assets to complete national balance sheets. The most widely used manual on capital stock estimation was published by OECD in 2001 (see OECD (2001)) and a revised edition, taking into account the developments and the 1993 revision of the System of National accounts (SNA), appeared in 2009 (see OECD (2009)).

The available approaches to calculate capital stock can be separated into two groups depending on the information that they use. The first group of methods uses mainly data relevant to the level of capital stock and does not consider investment information. Whereas the second group of models uses information both on the level of capital stock and gross investment flow. Current studies that

connect to the first group of methods are Bughin (1993) and Wolfson (1993) which use data from companies' book values from annual financial reports in order to proxy capital stock. Other economists use output capacity measures to obtain capital stock series among these are Lindquist (1995, 2000), Ohanian (1994), Reynolds (1986) and Lock (1985). Biorn et al. (1998) use stock exchange values as proxies of capital stock.

The major drawbacks of the first group of models are connected with the high costs related to the estimations, and limited availability and adequacy of the data. The most widely used approach in the empirical literature belongs to the second group of models and is called the Perpetual Inventory Model (PIM). This method is much cheaper than the directly observed methods since it takes into account only investment data that have to be combined with corresponding retirement and depreciation rates and some initial stock. Some examples are Hahn et al. (1984), Boehm et al. (2002), Costa et al. (1995). Little has been done to assess the effects of the *a priory* assumptions on initial stock and retirement rates in the PIM. There are only few studies among which Usher (1980), Miller et al. (1983), Barnhart et al. (1990) and Biorn et al. (1999).

In this paper we propose a new estimation method following a bottom up approach and try to model country specific non-financial assets estimates, and then compile the EA balance sheets. The paper is organized in the following way. Section two gives an overview on data availability by MUMS. Section three introduces the enhanced methodology used to estimate the institutional sector breakdown of each non-financial asset type for the EA. The results are included in section four. Section five concludes.

2. Data Availability

At this point in time there are only eight MUMS that report complete cross-classification of annual net capital stock by asset type and institutional sector (composing table 26[3]) representing 64% of Gross Fixed Capital Formation[4] (GFCF). These are Germany, France, Finland, Austria, Luxembourg, Latvia, the Netherlands, and Slovenia. In addition Italy, Estonia, Slovakia and Cyprus (17% of GFCF) publish institutional sector breakdown just for dwellings. Data for most MUMS covers the period between 1998 to 2012, however some breakdowns for Latvia are available for 2007 to 2010 only. A detailed description of data coverage, the classifications of the non-financial assets and institutional sectors can be found in the Annex A1 to A3.

Moreover 14 MUMS (all except Spain, Greece, Portugal and Malta) publish capital stock estimates for the total economy broken down by asset type and

[3] The main data source used in the presented estimations is the data collected under the European System of Accounts Transmission Programme (ESA TP). This data is collected by Eurostat and covers: Annual balance sheet for non-financial assets (table 26 of ESA TP); Cross classification of fixed assets by industry and assets-annual data (table 20 of the ESA TP); Cross classification of gross fixed capital formation by industry and assets-annual data (table 22 of the ESA TP).

[4] Reference year is 2013.

economic activity (composing table 20) [5]. This corresponds to around 87% of the euro area in terms of GFCF. Note that the timeliness of tables 20 and 26 under the ESA transmission programme is 24 month after the end of the reference year and are available on an annual basis only.

Gross fixed capital formation is reported by all 18 MUMS for the total economy broken down by asset type and economic activity (composing table 22). The valuation reported for GFCF is in constant prices and current prices, the time series are available at annual and quarterly frequency.

There is very sparse data on land (underlying dwellings) and households' housing wealth (HHW) for MUMS. National HHW data are available only for Germany, France, Italy, Spain and the Netherlands. These data are National Central Banks (NCB) estimates except for France and the Netherlands where the data comes from the respective national statistical offices.

3. Methodology

The most widely used estimation method for non-financial assets is based on the capital accumulation equations, which is also known as the Perpetual Inventory Method (PIM). The capital accumulation equation can be written as:

$$NCS_t = [1-(r_t + d_t)]NCS_{t-1} + GFCF_t \tag{1}$$

where r_t is retirement rate and d_t is depreciation for $t = 1...T$. Here NCS and $GFCF$ stands for Net Capital Stock and Gross Fixed Capital Formation respectively.

We can express (1) as a function of stock at the initial period $t = 1$ in the following way:

$$\begin{aligned} NCS_t &= (1-(r_t + d_t))NCS_{t-1} + GFCF_t \\ &= \sum_{j=2}^{T} GFCF_j \left[\prod_{s=j+1}^{T} (1-(r_s + d_s)) \right] + NCS_1 \prod_{i=2}^{T} (1-(r_i + d_i)) \end{aligned} \tag{2}$$

In order to calculate the EA capital stock series from equation (2) we have to estimate r_t, d_t and NCS_1 for the EA aggregate. The EA GFCF series are available at quarterly and annual frequency. There are two approaches that one can take in order to estimate EA capital stock – an "aggregate" approach (which was used in the past by ECB to estimate euro area capital stock) and a "bottom-up" approach (which is the enhancement in the estimation of euro area capital stock that this paper introduces). We will present the two approaches in the following sections.

[5] A detailed classification of economic activities is included in annex A4.

3.1 The "aggregate" approach for the estimation of euro area capital stock

The first approach tackles the estimation as an "aggregation" problem thus tying to estimate EA figures directly without using granularity on a MUMS level. The ECB implemented a similar approach in 2008 and used it until 2013 to estimate euro area capital stock estimates for the total economy including a breakdown by main asset type. The "aggregate" approach has several limiting assumptions. In order to estimate EA retirement and depreciation rates equation (1) is solved using the aggregated capital stock and gross fixed capital formation series from the MUMS reporting them. The estimated retirement and depreciation rates are assumed to hold for the capital stock aggregates for the EA. In order to calculate the initial net capital stock at $t = 1$ it is assumed that for the block of reporting MUMS the 'GDP-to-capital stock' ratio at time $t = 1$ is equal to the aggregate 'GDP-to-capital stock' ratio at time $t = 1$ for the EA. In addition the sector breakdown of the EA fixed assets series is done using the shares reported by the eight reporting MUMS.

The shaded areas in Table 1 show the institutional sectors and non-financial assets for which EA estimates can be obtained based on the "aggregate" method under the assumptions listed above. As one can see there is no breakdown into institutional sectors for all fixed assets.

Estimates of euro area non-financial assets by asset type and institutional sector using the "aggregate" method. The shaded areas represent the available estimates for the euro area

Table 1

Institutional Sector / Produced Non-Financial Assets (NFA)	Total economy (S1)	Non-financial corporations (S11)	Financial corporations (S12)	General government (S13)	Households and NPISH (S1M)
Fixed assets (AN.11)					
Dwellings (AN.1111)					
Other buildings and structures (AN.1112)					
Machinery and equipment (AN.1113)					
Other produced assets (AN.111N)					

The ''aggregation" approach is not optimal since MUMS have very heterogeneous non-financial assets allocations and corresponding depreciations. The two most important enhancements of the "aggregate" method are the sectorisation of all produced assets using all available country data and the estimation of the granular capital stock data on country level which then could be used for the compilation of the EA figures.

3.2 The bottom-up approach for the estimation of euro area capital stock

In the below proposed bottom-up approach, we consider each of the 18 MUMS separately and thus work on country level. In this way the non-financial balance sheet for each individual MUMS is obtained, the euro area figures are compiled based on the country data (reported or estimated).

3.2.1 Optimization Model to Obtain Full Sector Breakdown by Asset Type

As noted previously the main goal of this paper is to obtain non-financial asset type classification by sectors and such breakdown of the annual non-financial assets is reported only by eight MUMS.

Let's call all MUMS that report capital stock by asset type and institutional sector the *available countries*. The *missing countries* do not report such cross-classifications, but only total capital stock by asset type. In addition, for all 18 MUMS we have GFCF by asset type and industry breakdown. The model presented below is a two-step procedure which compiles a full institutional sector breakdown for each asset type, for each of the MUMS. The main assumption is that countries that have very similar industry breakdowns would have also similar sector breakdowns.

In the first step of the estimation we use data from table 22 of the ESA TP to estimate a measure that indicates how close the industry breakdown of each missing country is to the industry breakdown of each of the available countries.

Let's denote the different asset types with $AN = \{AN11, AN1111, AN1112, AN1113, AN111N\}$.[6] Each asset type is decomposed into industries denoted with $V = \{VA, VB, VC, \ldots, VU\}$.[7] Let's denote the data from the available countries with X_j where $j \in J$ indicates the reporting countries and data from the missing countries with Z_i with $i \in I$ indexing missing countries. The set of all reporting countries is denoted with J and the set of all missing countries is denoted with I. Then for each missing country i the following constrained linear least-squares problem is defined:

$$\min_{\alpha_{ij}^{AN}} \frac{1}{2} \left\| \alpha_{ij}^{AN} \sum_{j}^{J} (X_j)_V^{AN} - (Z_i)_V^{AN} \right\|_2^2 \tag{3}$$

$$subject\ to \begin{cases} \forall i \in I \quad \sum_j \alpha_{ij}^{AN} = 1 & (4) \\ \forall i \in I, \forall j \in J \quad 0 \le \alpha_{ij}^{AN} \le 1 & (5) \end{cases}$$

The two constraints that are imposed are needed so that the estimated $\hat{\alpha}_{ij}^{AN}$'s serve as a weighting measure that shows the similarities of the activity classification

[6] The notation that follows will be expressed in a matrix form, that is why the time dimension t will be dropped.

[7] The lists with all possible asset, sector and industry breakdowns are included the annexes A.2, A.3 and A.4.

between any available country j and missing country i. Note that equation (3) holds for each missing country i and asset type AN. Once the $\hat{\alpha}_{ij}^{AN}$ are estimated we can use them as a universe measure that relates also to the similarities of the institutional sector breakdown of the different countries. Knowing the breakdown for the assets for the available countries j, we can estimate the institutional sector breakdown of the missing counties i. Note that the capital stock for the total economy by asset type is known for most of the MUMS and is obtained from table 20. The total economy capital stock by asset for the few MUMS not reporting these data is estimated and will be discussed later on.

Let's denote the set of institutional sectors with $S = \{S_1, S_{11}, S_{12}, S_{13}, S_{1M}\}$.[8] Then for each $j \in J$ and AN we know the shares $\left\{ \left(\frac{S_{11}}{S_1}\right)_j^{AN}, \left(\frac{S_{12}}{S_1}\right)_j^{AN}, \left(\frac{S_{13}}{S_1}\right)_j^{AN}, \left(\frac{S_{1M}}{S_1}\right)_j^{AN} \right\}$. This information is obtained from table 26. For each i and AN we know $(S_1)_i^{AN}$ which are retrieved from table 20 or estimated. We assume that the similarities between the industry breakdowns also hold for the institutional sector breakdowns. In this way we can estimate $\left\{ \left(\hat{S}_{11}\right)_i^{AN}, \left(\hat{S}_{12}\right)_i^{AN}, \left(\hat{S}_{13}\right)_i^{AN}, \left(\hat{S}_{1M}\right)_i^{AN} \right\}$ based on the similarities of the breakdowns by industry $\hat{\alpha}_{ij}^{AN}$. For each i and asset type AN the following shares hold

$$\left(\frac{\hat{S}_{11}}{S_1}\right)_i^{AN} = \left[\sum_j \hat{\alpha}_{ij}^{AN} \left(\frac{S_{11}}{S_1}\right)_j^{AN}\right] \tag{6}$$

$$\left(\frac{\hat{S}_{12}}{S_1}\right)_i^{AN} = \left[\sum_j \hat{\alpha}_{ij}^{AN} \left(\frac{S_{12}}{S_1}\right)_j^{AN}\right] \tag{7}$$

$$\left(\frac{\hat{S}_{13}}{S_1}\right)_i^{AN} = \left[\sum_j \hat{\alpha}_{ij}^{AN} \left(\frac{S_{13}}{S_1}\right)_j^{AN}\right] \tag{8}$$

$$\left(\frac{\hat{S}_{1M}}{S_1}\right)_i^{AN} = \left[\sum_j \hat{\alpha}_{ij}^{AN} \left(\frac{S_{1M}}{S_1}\right)_j^{AN}\right]. \tag{9}$$

In this way we obtain a weighting matrix that can breakdown asset types into different institutional sectors for all MUMS. Once the country breakdown is obtained the EA asset type by institutional sector is calculated as accumulation of all country specific breakdowns. In order to obtain the quarterly estimates for capital stock we use quarterly series on investment (available for all EA countries) to perform Chow-Lin (1971) temporal disaggregation of the annual capital stock.

[8] Note that S1 = S11 + S12 + S13 + S1M. Detailed sector classifications are included in the Annex A3.

3.2.2 Estimating Total Economy Fixed Assets for the Non-reporting MUMS

As mentioned earlier there are four MUMS (Spain, Greece, Portugal and Malta) for which there is no data on capital stock, these countries are neither present in table 20 nor in table 26. For such countries we can obtain the similarity index as described above since it is based on GFCF classification for which we have full data coverage. But at the same time we are lacking the total economy capital stock by asset in order to do the break down into institutional sectors. In order to estimate the completely missing series on capital stock for the total economy we will use the initial "aggregate" PIM methodology, with several modifications, and apply it to the four MUMS listed above.

For the calculation of initial capital stock for the missing countries we used the ratio between the accumulated consumption of fixed capital (K1) to the accumulated capital stock for the reporting countries. Knowing K1 for the missing countries and using the calculated ratio we generate initial capital stock for each of the missing countries. We chose 2005 as a starting year in our accumulation equation and we forecast and backcast capital stock to cover the period 1998 to2013. For each of the reporting countries the retirement and depreciation rates were calculated using the PIM equation. For the missing countries the rates of the most "similar" reporting countries were taken into account. The similarity in gross fixed capital formation between countries was calculated using the Brey-Curtis distance[9].

A detailed sensitivity analysis on the selection of initial year of capital stock and the use of different retirement and depreciation rates is presented in the next section.

4. Results

4.1 The Enhanced Capital Stock Estimates for the Euro Area

In this section we present the results for the aggregated EA non-financial asset estimates. All of the series are at current prices. The result presented in this section cover the period from 1998 to 2013. Figure 1 displays the estimated capital stock by asset types broken down into institutional sectors. Figure 2 shows the asset composition for each sector. The new estimation allows for calculation of the sector breakdown for all types of the assets. In addition figure 3 shows the share distribution for the sectors for each of the asset groups.

As it can be seen from figures 1 to 3 the biggest portion of the fixed assets is owned by households and NPISH (on average around 42%) followed by the non-financial corporations (NFCs) (on average around 39%). The same order of the contributions of institutional sectors shares is observed for dwellings (on average around 85% for households and 13% for NFCs). As expected the largest shares for

[9] The index is composed based on country investment data for each non-financial asset. A detailed description is included in Annex A6. The Brey-Curtis measure is usually used to compare countries based on their trade structure.

other buildings are observed for NFCs and government, followed by households and financial corporations. Machinery and equipment is mostly build up by NFCs, with very small portions attributed to the other three sectors. Similar is the allocation of sectors' shares for the other produced assets.

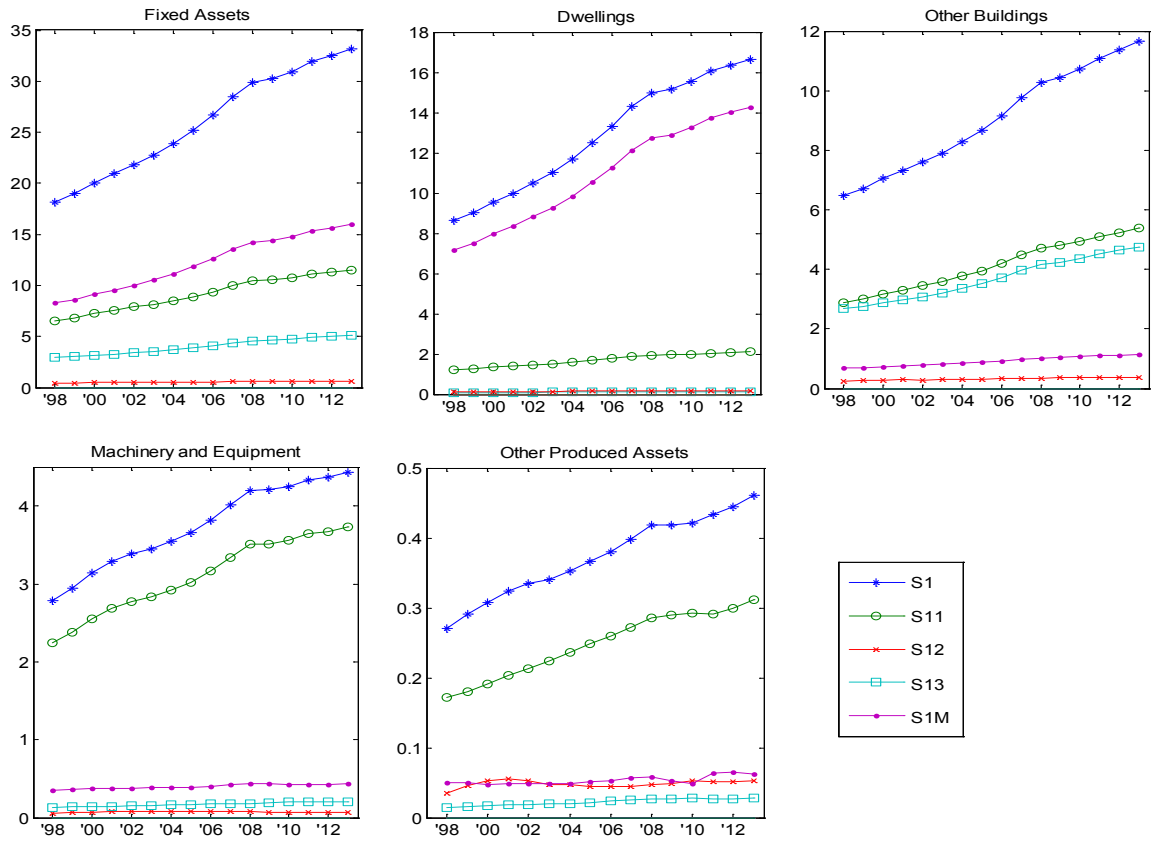
The proposed estimation method allows us to analyse the sector allocation of capital stock broken down into assets (see figure 2). The highest portion of total economy fixed assets is composed by the dwellings asset, which also applies to the households sector. On the other hand for the remaining three sectors (NFCs, general government, and financial corporations) the biggest contribution of capital stock is by other-buildings, followed by dwellings, machinery and other produced assets.

As it can be seen from figures 1 and 2 the time series are pretty stable with one exception. There is a slight fluctuation in capital stock for almost all of the series after 2008 which is due to the effect of the financial crisis. This is confirmed by figure 4, where the growth rates of the capital stock for the different sectors are displayed.

The biggest drop in growth rates in 2009 relative to 2007 occurred for the households sector. The growth rate of this sector shrank from 0.074 in 2007 to 0.012 in 2009 that is around 0.06 points in absolute terms.

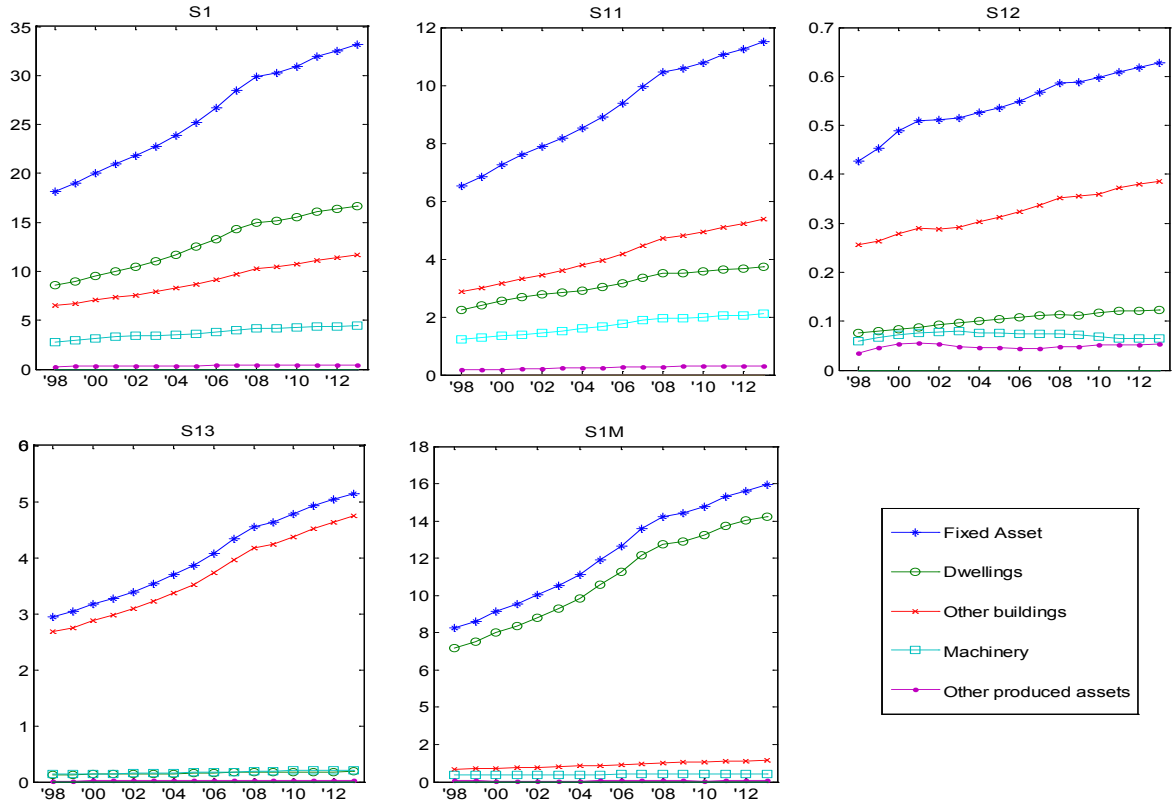
Net capital stock in current prices (levels, 1000 billions of euros) grouped by assets

Figure 1



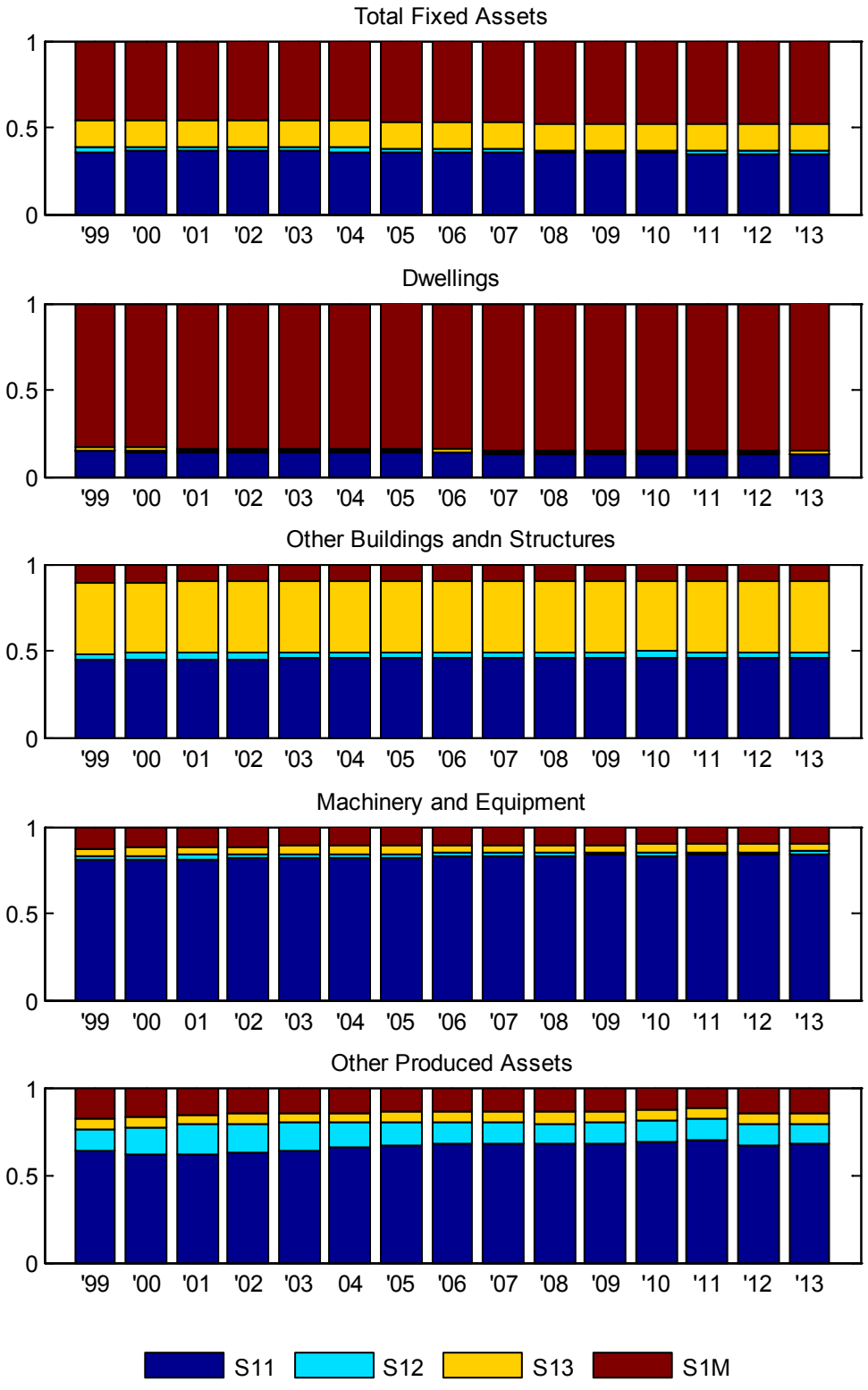
Net capital stock in current prices (levels, 1000 billions of euros) grouped by sectors

Figure 2



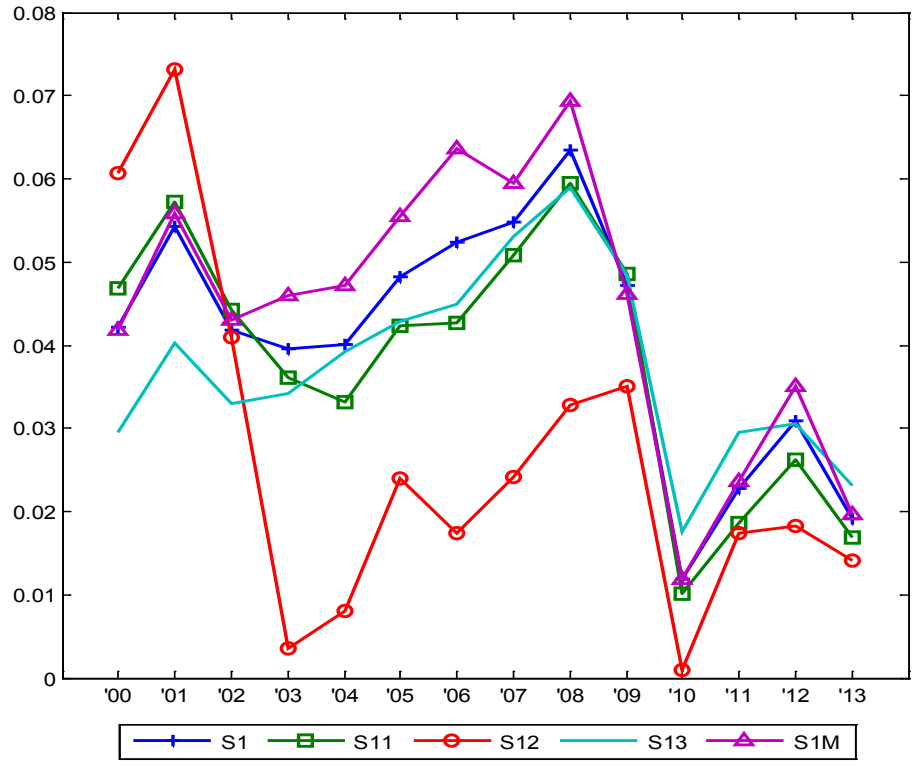
Shares of asset type capital stock into sectors

Figure 3



Fixed assets net capital stock in current prices (annual growth rates) grouped by sectors

Figure 4



In comparison the growth rate of capital stock for the financial corporation sector shrank from 0.035 in 2007 to 0.001 in 2009, which is around 0.03 points in absolute terms. The drop in the financial corporation's sector between 2000–2002 is explained by the stock market downturn in 2002, the so called dot-com bubble bursting.

4.2 Robustness checks

In this section we will discuss some of the assumptions implied earlier. First we will test the robustness of the presented optimization model, next we will examine the PIM assumptions introduced in 3.2.2.

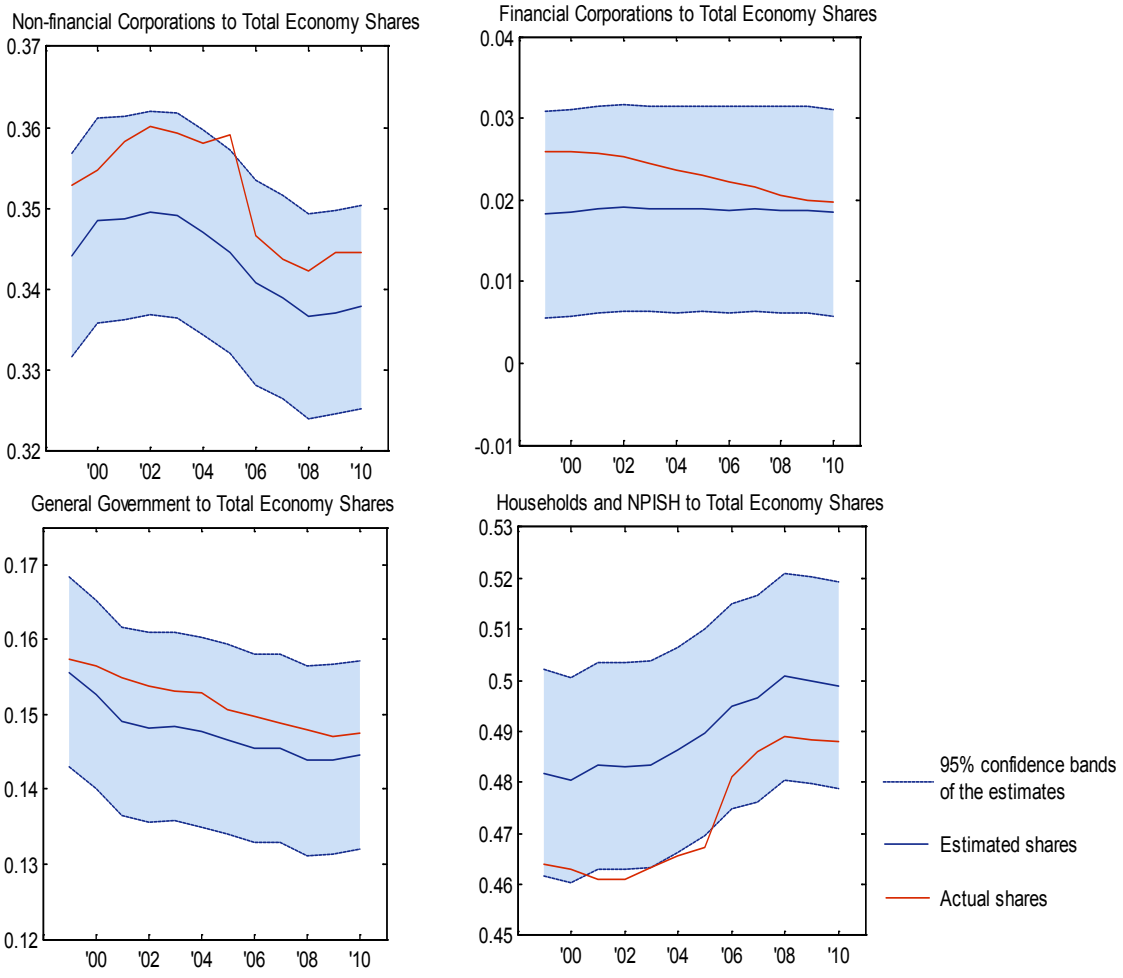
In order to make sure that the new model estimates correctly the shares of the different sectors with respect to the total economy stock, we performed the following experiment. For each of the MUMS for which we have an institutional sector breakdown for the fixed assets we tried to estimate this break down (countries that were considered include Germany, the Netherlands France, Finland, Austria, Latvia, Luxembourg and Slovenia). In a recursive exercise for each of the listed countries we estimated institutional sector breakdowns based on the remaining seven countries using the proposed model from 3.2.1. Figure 5 displays the results of the estimated and the actual shares along with the 0.95 percent confidence intervals of the accumulated estimates for the above countries. It can be seen that in a majority of the cases the actual shares lie within the confidence

intervals of the estimates, which confirms that following the proposed method one can estimate reliable institutional sector breakdown of the EA aggregate.

The PIM assumptions that were presented in the methodology section 3.2.2 are also tested in order to obtain the most accurate capital stock estimate. As stated earlier the year 2005 was chosen as initial year of the PIM from where we forecasted and backcasted capital stock. Then the ratio consumption of fixed capital to fixed assets from reporting MUMS was used to estimate initial capital stock for missing MUMS.

Sector shares relative to the total economy for the net capital stock of fixed assets

Figure 5



In order to justify these assumptions we evaluated different methods to generate initial capital stock in different starting years. We considered the MUMS for which we have data and tried to estimate initial stock for each one of them on the basis of the rest of the available stock. We then generated the accumulated stock estimates for the available MUMS and calculated the Root Mean Square Error (RMSE) of the forecast at each initial year relative to the actual stock values. Table 2

present the results. It can be concluded that the best method to generate initial stock is to use the consumption of fixed capital to capital stock ratio for 2005. The poorly performing alternative methods considered different functions of investment or GDP to capital stock ratios.

RMSE of capital stock estimates of reporting countries. The three minimum values are indicated with stars. GDP=gross domestic product, CS=capital stock, I=GFCF, K1=consumption of fixed capital

Table 2

	Method				
Year	GDP/CS	I/CS	sum(I)/CS	sum(I-K1)/CS	K1/CS
1998	0.0380	0.0545	0.0205	0.0446	0.0572
1999	0.0389	0.0413	0.0364	0.0271	0.0367
2000	0.0034	0.0028	0.0065	0.0120	0.0029
2001	0.0029	0.0036	0.0056	0.0124	0.0025
2002	0.0027	0.0039	0.0048	0.0127	0.0023
2003	0.0025	0.0040	0.0041	0.0126	0.0022***
2004	0.0025	0.0034	0.0030	0.0136	0.0019**
2005	0.0025	0.0037	0.0026	0.0134	0.0018*
2006	0.0026	0.0037	0.0027	0.0131	0.0024
2007	0.0027	0.0041	0.0026	0.0127	0.0024
2008	0.0028	0.0043	0.0025	0.0129	0.0027
2009	0.0384	0.0270	0.0419	0.0096	0.0454
2010	0.0418	0.0371	0.0311	0.0129	0.0536
2011	0.0395	0.0285	0.0456	0.0426	0.0529
2012	0.4330	0.4810	0.1011	0.1218	0.0920

Brey-Curtis similarity distance between missing countries and reporting countries. The stared distances are the minimum distance measures indicating similarity between the missing and reporting countries

Table 3

	Missing countries			
Reporting countries	Spain	Portugal	Greece	Malta
Italy	0.157	0.152*	0.202	0.143*
Slovakia	0.329	0.284	0.340	0.307
Estonia	0.179	0.166	0.196	0.164
Belgium	0.168	0.189	0.219	0.173
Cyprus	0.110*	0.158	0.140*	0.190
Austria	0.167	0.172	0.195	0.189
The Netherlands	0.143	0.161	0.142	0.211
Slovenia	0.221	0.164	0.242	0.201
Finland	0.202	0.210	0.224	0.230
Germany	0.201	0.223	0.271	0.177
France	0.161	0.185	0.209	0.214
Ireland	0.252	0.194	0.200	0.286

Once the initial capital stock is estimated for the non-reporting MUMS we have to choose retirement and depreciation rates that enter the accumulation equations. We use the Brey-Curtis distance measure to compare the distribution of investment within industries between all countries. Table 3 present results. The lower score indicates stronger similarity which means that the retirement and depreciation rates between the countries with low scores should be similar. We followed the results from table 3 and for Spain and Greece we used the retirement and depreciation rates from Cyprus, for Portugal and Malta we used the rates from Italy.

4.3 The Enhanced Capital Stock Estimates' Relevance to Monetary Policy

In this section we discuss on the importance of capital stock figures as building element of housing wealth and its relevance to monetary policy. Maintaining price stability is the main goal of monetary policy which is achieved through the reactions of households and non-financial corporations sectors to Central Banks' monetary policy initiatives (Bull, 2013). Monitoring developments in these sectors, and across MUMS, is therefore of key interest and balance sheet information, including non-financial assets, contributes to the quality and range of sector analysis.

Also, wealth is an important variable in many respects, one of them being the possible link to household consumption (see for example Baker (2011), Kerdrain (2011), Sousa (2009), Skudelny (2009)). First, economic agents could use part of their accumulated assets to finance current consumption expenditure. Second, wealth could be used as collateral to borrow against. In particular households can offer non-financial wealth (housing) as collateral, which would ease their access to credit in case credit supply is constrained.

Households' net worth (National Accounts terms for household wealth) is calculated as the sum of financial assets (+), non-financial assets (+) and financial liabilities (–), thus measures the excess of households' assets over households' liabilities. A time series presentation of households' net worth provides balance sheet strengths (or weaknesses) of households at given points in time. In turn, it shows the impact of transactions and price changes on the stocks of households' assets and liabilities.

In general, statistics on stocks of financial assets and liabilities are more common than those on non-financial assets, more in particular statistics on housing wealth, mainly because they are reported on a voluntary basis or with a generous timeliness. To arrive at housing wealth, one should complement the estimates on dwellings with the value of land underlying the dwelling. Usually land is estimated using administrated data or surveys. Alternatively land can be estimated as residual of households' housing wealth (HHW) and households' dwelling stock. In the current estimates we use available national data on HHW to calculate the average ratio of net HHW over net dwelling stock. [10] This ratio is subsequently used to

[10] Official series up to 2012 (except Spain: 2013) are published for Germany, France, Italy, Spain, the Netherlands and Belgium. In addition, figures for Greece, up to 2001, were taken from the "Monetary Policy Report" of the Bank of Greece, November 2002, provisional estimates for 2002–2005 were provided by Bank of Greece, data after 2005 was estimated by extrapolation using residential property prices and housing investment.

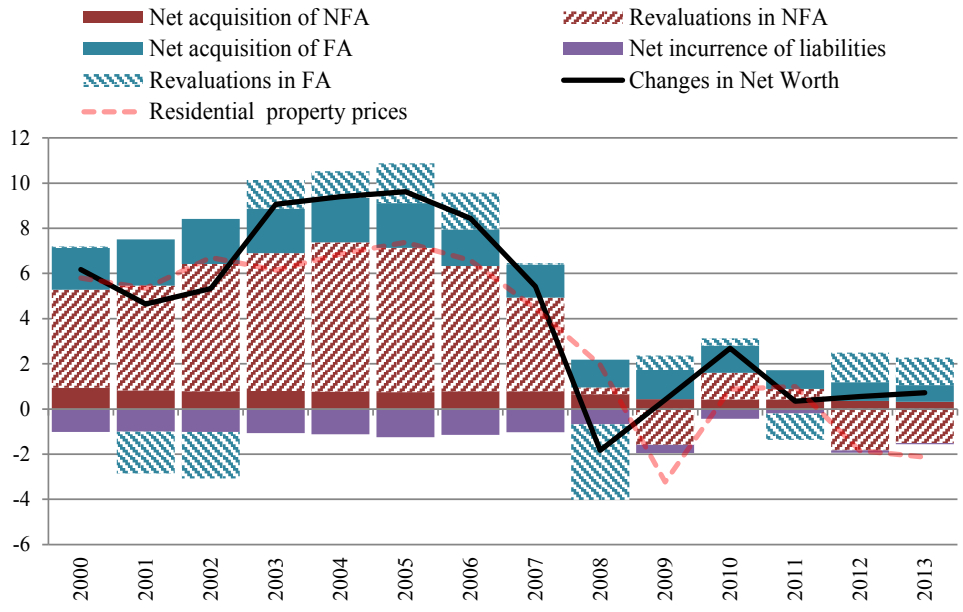
estimate HHW for non-reporting MUMS. Next, the EA HHW is estimated as aggregate of the reported MUMS HHW and the estimated ones.

Annex A.6 shows households' wealth in the euro area, broken down by type of asset. Non-financial assets are by far the largest component (60%) of gross wealth (sum of financial and non- financial assets) and accounted for most of the marked pre-crisis growth (2000–2007). The importance increased significantly since 2000, mainly due to increasing property prices.

This also becomes clear from Figure 6, which decomposes growth of euro area households' net worth into household transactions and valuation changes. Valuation changes (or holding gains and losses) account for most of the changes in households' net worth, notably those of non-financial assets. However, holding losses, reflecting negative stock price developments, contributed significantly to the marked deceleration and fall of households' net worth in 2008, leading the price fall of non-financial assets (e.g. houses) in 2009. Net acquisitions of assets and incurrence of liabilities provide a fairly stable, though modest contribution. From 2007 onward the growth of net incurrence of liabilities decelerates, reflecting the deleveraging process of euro area households.

Household wealth is unevenly distributed among MUMS and its developments are quite heterogeneous across countries (see Annex A.7 and Figure 7). This implicates that a single euro area (monetary) policy may have different impact on euro area economies. Annex A.7 shows the main wealth characteristics for Germany, France, Italy, Spain, the Netherlands and Greece. Figure 7 shows the developments of net worth, financial and non-financial assets and financial liabilities in EA and selected countries from 2000 onward. The housing boom-bust cycle is clearly observed for Spain, Greece and the Netherlands, pushing down their non-financial wealth to pre-crisis levels. Developments of financial assets are less dispersed, as their prices (valuation changes) follow general market trends that are mostly determined at euro area, and more likely, even global levels, rather than within a single country.

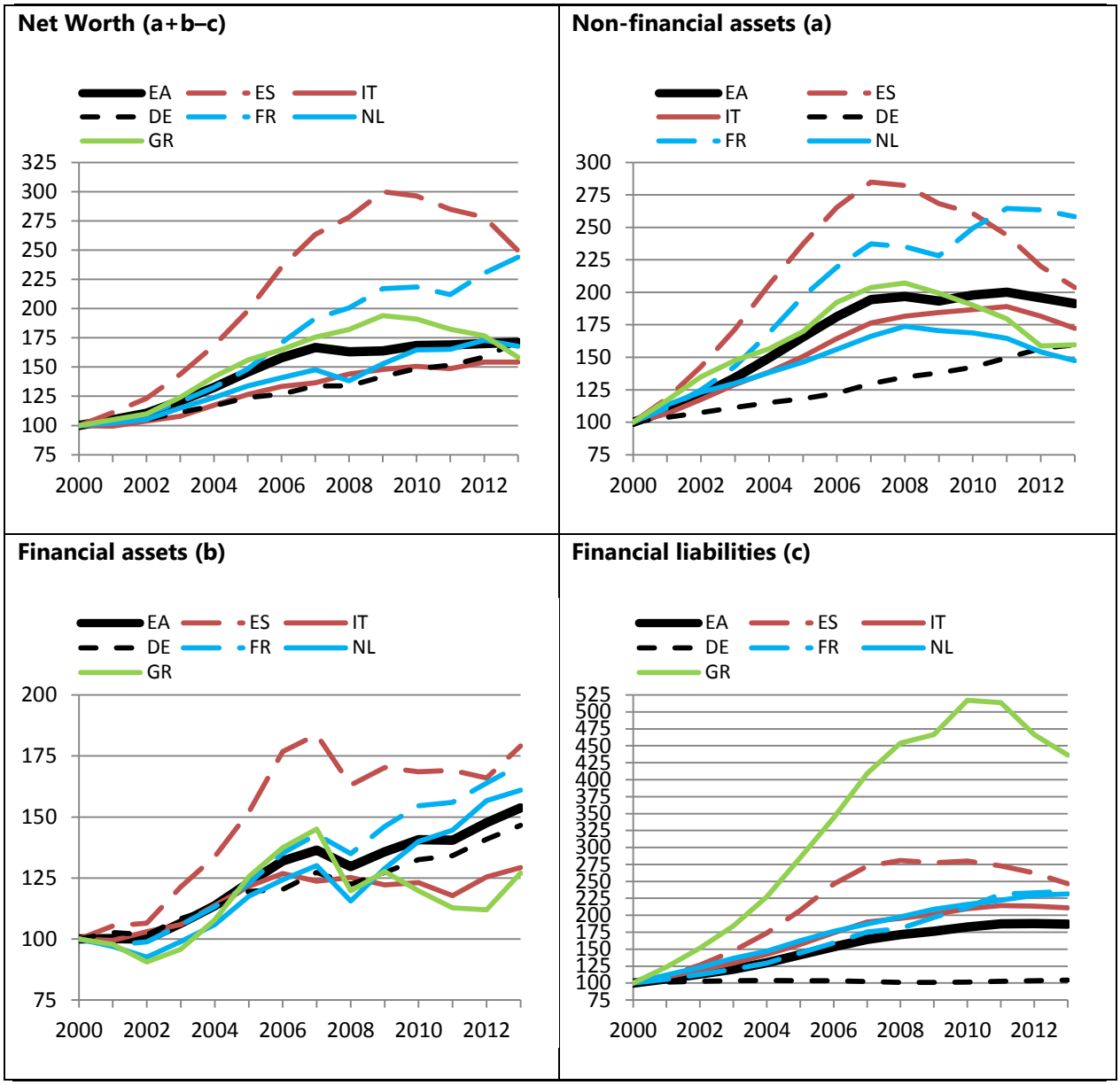
Growth of Euro Area households' net worth and contributions by asset type — Figure 6



Developments of households' net worth and its components in the euro are and selected countries

(index number: 2000=100)

Figure 7



5. Conclusion

Contrary to data on financial assets, official euro area wide statistics on non-financial assets by asset types and sectors are neither yet available nor with a feasible timeliness, but very useful for economic and financial stability analysis, since they complete sectors' balance sheets. This paper proposes a constrained optimization model with the help of which a full cross-sector classification of capital stock can be estimated. The model is applied for the estimation of capital stock by institutional sector, including households' non-financial asset type and households' housing wealth both for the euro area and euro area Member States currently not estimating and/or publishing such data.

Annex

A.1:Data availability tables 20, 22 and 26 of the ESA95 Transmission Programme

Table 20 Availability by type of non-financial assets

GEO	AN11	AN1111	AN1112	AN1113	AN111N
Belgium	2000-2012	2000-2012	2000-2012	2000-2012	2000-2012
Germany	2000-2011	2000-2011	2000-2011	2000-2011	2000-2011
Estonia*	2000-2011	2000-2011	2000-2011	2000-2011	2000-2011
Ireland	2000-2011	2000-2011	2000-2011	2000-2011	2000-2011
Greece	X	X	X	X	X
Spain	X	X	X	X	X
France	1998-2012	1998-2012	1998-2012	1998-2012	1998-2012
Italy	1998-2012	1998-2012	1998-2012	1998-2012	1998-2012
Cyprus*	1998-2012	1998-2012	1998-2012	1998-2012	1998-2012
Latvia	2007-2010	2007-2010	2007-2010	2007-2009	2007-2010
Luxembourg	1998-2011	1998-2011	1998-2011	1998-2011	1998-2011
Malta	X	X	X	X	X
Netherlands	2000-2012	2000-2012	2000-2012	2000-2012	2000-2012
Austria	1998-2012	1998-2012	1998-2012	1998-2012	1998-2012
Portugal**	2005	2005	2005	2005	2005
Slovenia	2000-2011	2000-2011	2000-2011	2000-2011	2000-2011
Slovakia	2004-2012	2004-2012	2004-2012	2004-2012	2004-2012
Finland	1998-2012	1998-2012	1998-2012	1998-2012	1998-2012

*Some figures are missing for 2011

** Total NACE only

Table 22 Availability by type of non-financial assets

GEO	AN11	AN1111	AN1112	AN1113	AN111N
Belgium	1998-2013	1998-2012	1998-2013	1998-2013	1998-2013
Germany	1998-2013	1998-2013	1998-2013	1998-2012	1998-2013
Estonia	1998-2013	1998-2013	1998-2013	1998-2013	1998-2013
Ireland	1998-2012	1998-2012	1998-2012	1998-2012	1998-2012
Greece	2000-2013	2000-2013	2000-2013	2000-2013	2000-2013
Spain	1998-2013	1998-2013	1998-2013	1998-2013	1998-2013
France	1998-2013	1998-2013	1998-2013	1998-2013	1998-2013
Italy	1998-2013	1998-2013	1998-2013	1998-2013	1998-2013
Cyprus	1998-2013	1998-2013	1998-2013	1998-2012	1998-2012
Latvia	1998-2013	1998-2013	1998-2013	1998-2013	1998-2013
Luxembourg	1998-2013	1998-2013	1998-2013	1998-2013	1998-2013
Malta	1998-2013	1998-2013	1998-2013	1998-2013	1998-2013
Netherlands	1998-2013	1998-2013	1998-2013	1998-2013	1998-2013
Austria	1998-2013	1998-2013	1998-2013	1998-2013	1998-2013
Portugal	1998-2013	1998-2013	1998-2013	1998-2013	1998-2013
Slovenia	1998-2013	1998-2013	1998-2013	1998-2013	1998-2013
Slovakia	1998-2013	1998-2013	1998-2013	1998-2013	1998-2013
Finland	1998-2013	1998-2013	1998-2013	1998-2013	1998-2013

Table 26 Availability by type of non-financial assets

GEO	AN11	AN1111	AN1112	AN1113	AN111N
Germany	1998-2012	1998-2012	1998-2012	1998-2012	1998-2012
Estonia	X	2000-2011	X	X	X
France	1998-2012	1998-2012	1998-2012	1998-2012	1998-2012
Italy	X	1998-2012	X	X	X
Cyprus*	X	1998-2011	X	X	X
Latvia	2000-2010	2007-2010	2007-2010	2007-2010	2000-2010
Luxembourg	1998-2012	1998-2012	1998-2012	1998-2012	1998-2012
Netherlands	1998-2012	1998-2012	1998-2012	1998-2012	1998-2012
Austria	1998-2012	1998-2012	1998-2012	1998-2012	1998-2012
Slovenia	2000-2011	2000-2011	2000-2011	2000-2011	2000-2011
Slovakia	X	1998-2012	X	X	X
Finland	1998-2012	1998-2012	1998-2012	1998-2012	1998-2012

*sector allocation only available for AN1111

A.2 Non-financial assets classification

AN.1	Produced Assets
AN.11	Fixed assets
AN.111	Tangible fixed assets
AN.1111	Dwellings
AN.1112	Other buildings and structures
AN.11121	Non-residential buildings
AN.11122	Other structures
AN.1113	Machinery and equipment
AN.11131	Transport equipment
AN.11132	Other machinery and equipment
AN.1114	Cultivated assets
AN.11141	Livestock for breeding, dairy, draught, etc.
AN.11142	Vineyards, orchards and other plantations of trees yielding repeat products
AN.112	Intangible fixed assets
AN.1121	Mineral exploration
AN.1122	Computer software
AN.1123	Entertainment, literary or artistic originals
AN.1129	Other intangible fixed assets
AN.111N	Cultivated assets plus intangible fixed assets (N1114 + N112)
AN.12	Inventories
AN.121	Materials and supplies
AN.122	Work in progress
AN.1221	Work in progress on cultivated assets
AN.1222	Other work in progress
AN.123	Finished goods
AN.124	Goods for resale
AN.13	Valuables
AN.131	Precious metals and stones
AN.132	Antiques and other art objects
AN.139	Other valuables

A.3 Sector classification

S1	Total economy
S11	Non-financial corporations
S12	Financial corporations
S13	General government
S1M	Households and NPISH

A.4 Economic activity classification

V	Total
VA	Agriculture, forestry and fishing
VB	Mining and quarrying
VC	Manufacturing
VD	Electricity, gas, steam and air conditioning supply
VE	Water supply, sewerage, waste management and remediation activities
VF	Construction
VG	Wholesale and retail trade; repair of motor vehicles and motorcycles
VI	Accommodation and service activities
VH	Transportation and storage
VJ	Information and communication
VK	Financial and insurance activities
VL	Real estate activities
VM	Professional, scientific and technical activities
VN	Administrative and support service activities
VO	Public administration and defence; compulsory social security
VP	Education
VQ	Human health and social work activities
VR	Arts, entertainment and recreation
VS	Other service activities
VT	Activities of households as employers; undifferentiated goods- and service-producing activities of households for own use
VU	Activities of extraterritorial organisations and bodies

A.5 Bray Curtis distance measure

Bray-Curtis distance measure used usually to measure similarity between countries' trade structures, here it is used for comparing investment structures. We will follow the same notation as in 3.2.2. The index measures the distance between two countries investment composition for certain asset using its industry shares (Data source Table 22). Mets denote with $(R_i)^{AN}_{Y}$ the investment ratio of industry *V* in asset AN for country *i* relative to the total investment in this asset. Thus the Bray-Curtis distance measure between countries *i* and *j* can be written as:

$$\beta_{ij}^{N} = \frac{\sum_{V} \left| (R_i)_V^{AN} - (R_j)_V^{AN} \right|}{\sum_{V} \left[(R_i)_V^{AN} + (R_j)_V^{AN} \right]}$$

Lower values indicate shorter distance thus greater similarity.

A.6 Households' net worth in the euro area (2000–2013)

Wealth component	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	*2000-07 average*	*2007-1 averag*
Amounts *(€ bln, current prices)*																
Financial assets (a)	13445	13466	13438	14312	15275	16533	17733	18330	17429	18249	18935	18879	19751	20538		
Non-financial assets (b)	15483	16860	18557	20475	22713	25080	27382	29328	29726	29254	29907	30280	29659	29152		
of which: housing wealth	14336	15681	17348	19232	21423	23750	25994	27868	28203	27727	28370	28696	28055	27435		
Gross wealth (a+b)	28928	30326	31995	34787	37987	41613	45115	47658	47155	47503	48842	49159	49410	49690		
Liabilities (c)	3683	3907	4168	4438	4784	5216	5647	6050	6311	6492	6729	6901	6921	6895		
Net worth (a+b-c)	25245	26419	27826	30349	33203	36397	39468	41608	40844	41011	42113	42257	42489	42795		
Net worth as a % of disposable income	*589%*	*592%*	*593%*	*625%*	*662%*	*700%*	*734%*	*743%*	*699%*	*679%*	*700%*	*695%*	*684%*	*686%*		
Net worth per capita (1000 euro)	*80.5*	*83.9*	*88.0*	*95.5*	*103.8*	*113.1*	*121.9*	*127.8*	*124.7*	*124.6*	*127.5*	*127.6*	*127.9*	*128.5*		
Wealth composition *(as a percent of total gross wealth)*																
Financial assets (a)	46.5	44.4	42.0	41.1	40.2	39.7	39.3	38.5	37.0	38.4	38.8	38.4	40.0	41.3		
Non-financial assets (b)	53.5	55.6	58.0	58.9	59.8	60.3	60.7	61.5	63.0	61.6	61.2	61.6	60.0	58.7		
of which: housing wealth	49.6	51.7	54.2	55.3	56.4	57.1	57.6	58.5	59.8	58.4	58.1	58.4	56.8	55.2		
Gross wealth (a+b)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		
Liabilities to gross wealth	12.7	12.9	13.0	12.8	12.6	12.5	12.5	12.7	13.4	13.7	13.8	14.0	14.0	13.9		
Annual growth *(year on year percentage change)*																
Financial assets	3.5	0.2	-0.2	6.5	6.7	8.2	7.3	3.4	-4.9	4.7	3.8	-0.3	4.6	4.0	*4.5*	*2.*
Non-financial assets	8.8	8.9	10.1	10.3	10.9	10.4	9.2	7.1	1.4	-1.6	2.2	1.2	-2.1	-1.7	*9.6*	*-0.*
of which: housing wealth	9.3	9.4	10.6	10.9	11.4	10.9	9.4	7.2	1.2	-1.7	2.3	1.1	-2.2	-2.2	*10.0*	*-0.*
Gross wealth	6.3	4.8	5.5	8.7	9.2	9.5	8.4	5.6	-1.1	0.7	2.8	0.6	0.5	0.6	*7.4*	*0.*
Liabilities	6.9	6.1	6.7	6.5	7.8	9.0	8.3	7.1	4.3	2.9	3.6	2.6	0.3	-0.4	*7.3*	*2.*
Net worth	6.2	4.6	5.3	9.1	9.4	9.6	8.4	5.4	-1.8	0.4	2.7	0.3	0.5	0.7	*7.4*	*0.*

A.7 Households key indicators by country (2000–2013)

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
% Contribution to euro area net worth														
Germany	25%	25%	24%	23%	23%	22%	21%	20%	20%	20%	21%	21%	22%	23%
France	19%	19%	19%	20%	20%	21%	22%	22%	22%	22%	22%	23%	24%	24%
The Netherlands	7%	7%	7%	7%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
Italy	22%	22%	21%	21%	21%	20%	20%	20%	19%	20%	20%	19%	19%	19%
Spain	11%	11%	12%	13%	14%	15%	16%	16%	17%	16%	16%	15%	14%	13%
Greece	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	2%	2%
Net worth as a % of HGDI														
Germany	446	445	446	461	473	486	488	514	503	523	528	527	542	547
France	518	513	527	575	627	691	732	745	698	693	733	738	743	741
The Netherlands	809	748	724	760	793	838	859	864	802	848	871	858	873	873
Italy	663	643	657	674	697	726	745	736	738	754	757	728	737	717
Spain	663	710	764	844	927	982	1030	1023	917	885	884	840	794	791
Greece	698	729	755	749	752	775	797	759	717	702	706	712	719	818
Net worth per capita (1000 euro)														
Germany	75.4	77.8	78.8	83.1	86.7	91.1	93.6	100.5	101.3	105.3	109.7	113.6	119.5	122.9
France	80.3	83.1	88.6	98.4	111.3	125.4	137.9	146.6	141.2	140.4	150.7	155.2	156.9	157.2
The Netherlands	112.8	114.0	112.5	117.6	124.6	134.0	141.2	148.1	138.2	143.9	149.1	148.6	150.4	151.1
Italy	96.3	98.5	104.6	109.9	116.6	124.3	131.4	133.2	135.0	133.5	134.4	131.5	130.4	126.8
Spain	69.4	78.4	88.4	102.9	118.6	133.2	147.2	153.0	144.3	139.0	134.8	127.9	117.4	116.7
Greece	64.8	71.2	77.0	82.8	88.0	95.5	106.2	111.0	106.0	104.0	97.2	91.6	83.6	85.5
Share of housing wealth in gross wealth														
Germany	48%	49%	50%	49%	49%	49%	49%	49%	51%	51%	51%	51%	51%	51%
France	50%	53%	56%	58%	60%	62%	62%	63%	64%	61%	62%	63%	62%	60%
The Netherlands	32%	37%	42%	43%	42%	41%	41%	42%	46%	46%	44%	43%	41%	38%
Italy	45%	47%	48%	50%	50%	50%	51%	54%	54%	55%	55%	56%	54%	53%
Spain	64%	67%	71%	72%	73%	74%	73%	74%	75%	74%	73%	72%	70%	66%
Greece	66%	70%	74%	75%	74%	73%	73%	73%	77%	75%	75%	75%	73%	71%
Share of debt (liabilities) in gross wealth														
Germany	20%	19%	19%	19%	18%	17%	17%	16%	16%	15%	15%	14%	14%	14%
France	11%	11%	11%	11%	10%	10%	10%	10%	11%	12%	12%	13%	12%	12%
The Netherlands	17%	18%	20%	21%	21%	21%	22%	22%	24%	24%	24%	25%	25%	25%
Italy	7%	8%	8%	8%	8%	9%	9%	9%	10%	10%	10%	10%	10%	11%
Spain	11%	11%	11%	10%	11%	11%	12%	12%	13%	13%	13%	14%	14%	14%
Greece	4%	4%	5%	6%	6%	7%	8%	9%	10%	11%	12%	13%	13%	12%
Households' savings ratio														
Germany	15%	15%	16%	16%	16%	16%	16%	17%	17%	17%	17%	16%	16%	16%
France	14%	15%	16%	15%	15%	14%	15%	15%	15%	16%	16%	16%	15%	15%
The Netherlands	12%	15%	14%	13%	13%	12%	12%	13%	12%	12%	10%	12%	11%	11%
Italy	14%	16%	17%	16%	17%	16%	16%	15%	15%	14%	12%	12%	12%	13%
Spain	11%	11%	11%	12%	11%	11%	10%	10%	14%	18%	14%	13%	10%	10%
Greece	3%	2%	0%	1%	1%	5%	5%	8%	2%	3%	-2%	-4%	-5%	0%

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