BANK OF GREECE

EUROSYSTEM

Working Paper

Housing wealth, household debt and financial assets: are there implications for consumption?

Konstantina Manou

Panagiotis Palaios

Evangelia Papapetrou

263

JUNE 2019

WORKINGPAPERWORKINGPAPERWORKINGPAPERWORKINGPAPERWORK

BANK OF GREECE
Economic Analysis and Research Department – Special Studies Division
21, E. Venizelos Avenue
GR-102 50 Athens
Tel: +30210-320 3610
Fax: +30210-320 2432

www.bankofgreece.gr

Printed in Athens, Greece
at the Bank of Greece Printing Works.
All rights reserved. Reproduction for educational and
non-commercial purposes is permitted provided that the source is acknowledged.

ISSN 1109-6691

HOUSING WEALTH, HOUSEHOLD DEBT AND FINANCIAL ASSETS: ARE THERE IMPLICATIONS FOR CONSUMPTION?

Konstantina Manou
Bank of Greece

Panagiotis Palaios
National and Kapodistrian University of Athens

Evangelia Papapetrou
Bank of Greece and National and Kapodistrian University of Athens

Abstract

This paper evaluates the asymmetric transmission effects of housing wealth, household debt and financial assets on consumption spending in Greece over the period 1999Q4 to 2017Q4. We apply the Enders and Siklos (2001) methodology and use Stevans's (2004) modification to capture these effects in a multivariate framework. Our results show that consumption responds asymmetrically to all types of changes applied. We provide evidence for the predominance of negative changes compared to positive ones. Our empirical findings are consistent with a stronger consumption response to decreases in financial assets and housing wealth. Furthermore, our results add to the existing literature in that the driving force of the rapidly reducing consumption spending is the deleveraging change. We also check the robustness of our results by applying Hansen's (2017) kink regression model analysis. The empirical results provide evidence that consumption and wealth component data fit better a threshold model than a linear model.

Keywords: Consumption, financial wealth, housing wealth, household debt, asymmetric adjustment
JEL Classification: E21, E44, D12

Acknowledgements: The authors are grateful to Stephen Hall and Heather Gibson for helpful comments and suggestions. The views expressed are those of the authors and not those of their respective institutions.

Correspondence:
Evangelia Papapetrou
Economic Analysis and Research
Bank of Greece
21 El. Venizelos Avenue
10250 Athens, Greece
Tel.: +30 210 320 2377
email: epapapetrou@bankofgreece.gr

1. Introduction

The wealth effect on private consumption is traditionally analyzed through the permanent income hypothesis model (Friedman, 1957) and the life-cycle model (Ando and Modigliani, 1963) according to which consumers use their lifetime disposable income and financial wealth to smooth consumption. These models are based on the assumption that credit markets work perfectly, consumers do not face liquidity constraints and, as a result, consumers adjust their consumption to positive and negative changes out of income and out of wealth components at the same rate. The main transmission channels are the wealth effect, implying sales of assets to strengthen consumption and the collateral effect, implying that wealth elements can be used as collateral in a loan, thus allowing consumers to smooth consumption over the life cycle. These intertemporal models of consumption predict a positive and linear relationship among private consumption spending, disposable income and wealth components.

The bulk of work to examine the effect of household wealth on consumption has focused mainly on the US experience (Cooper and Dynan, 2016; Poterba, 2000; Marquez et al., 2014) although there is a growing interest to experiences in other countries (Afonso and Sousa, 2011; Barell et al., 2015). To examine the outcome of household wealth on consumption most studies have utilized different types of data and structures including macroeconomic time series, cross-country comparisons, household survey data, credit-record data and cross-country comparisons (Cooper and Dynan, 2016). The study of the relationship has regained increased interest as wide fluctuations in household wealth, financial and real, in terms of changes in the value of financial wealth and house prices in most industrialized countries over the last two decades triggered new interest. The work on wealth effects on consumption during and after the recent housing boom is vast and most studies identify different responses of consumer spending to the two types of wealth. Most studies identify a larger effect for housing than for financial wealth. Mian et al., (2013) identify important housing wealth effects during the housing boom. Sierminska and Takhtamanova (2012) using harmonized wealth micro data for Canada, Finland, Italy, Germany and the US claim that the effect of housing wealth dominates the effect of financial wealth in Finland, Italy, Germany, the US, and also in Canada for certain age groups. Though, De Bonis and Silvestrini (2012) show that both net financial wealth and real wealth have a positive effect on consumption but overall, the influence of net financial assets is stronger than the influence of real assets. Rodriguez-Palenzuela and Dees (2016) identify important real estate effects on consumption for many European countries. Navarro and de Frutos (2015) show that both types of wealth are important but the financial wealth effect dominates that of the housing wealth while in the long run both effects become similar. Kichian and Mihic (2018) show that financial and housing wealth have significant effects on consumption in Canada and the financial wealth effects are larger than housing wealth effects. Arrondel et al., (2019) provide evidence that the financial wealth effect dominates the housing asset effect, however this finding is weak at the top of the wealth distribution.

However, as household net wealth (worth) depends on its financial liabilities that is the debt it holds, wealth effects are not solely associated with movements in asset prices, such as financial and real assets (Cooper and Dynan, 2016). Recent evidence suggests that over the last two decades in many developed countries increases in housing wealth and financial wealth were associated with increases in household debt. A growing amount of literature aims at evaluating whether increasing household debt had an impact on output growth, employment and household consumption. Mian et al., (2017) show that countries with higher household debt experience a sharper decline in growth after an increase in domestic household debt and Mian and Sufi (2014) show that household deleveraging is responsible for the job losses in the 2007-2009 period in the U.S. Similarly, Dynan (2012) document that high household debt or leverage had a negative impact on consumption during the Great Recession in the US. Baker (2014) finds that spending by highly indebted households was more sensitive to income changes than spending by other households. Mian et al., (2013) using regional data show that leverage intensified the negative wealth effect on consumption in areas with declining house prices. Bunn and Rostom (2014) employing microdata for the UK show that high levels of household debt were associated with deeper downturns and more protracted recoveries while Andersen et al., (2016) report an amplified negative correlation between high leveraged households and consumption during the crisis in

Denmark. McCarthy and McQuinn (2017) claim that the decision of households to deleverage had negative implications for consumption in Ireland.

Within this context, the present study analyzes the relationship between household consumption expenditure and household net wealth components. For this reason, we estimate the underlying relationship using disposable income and housing wealth, household debt (financial liabilities) and financial assets as regressors. Aiming to account for possible asymmetric linkages, we apply threshold autoregressive methodology initially proposed by Enders and Siklos (2001) and further developed by Stevans (2004). To this direction, a unique data set is employed that covers the period 1999Q4 to 2017Q4 for Greece. Our results provide strong evidence in favor of a long-run equilibrium relationship among household net wealth components and consumption spending in Greece. Employing housing wealth, household debt and financial assets as threshold variables we also find evidence of multiple asymmetric effects on consumption. We show that the elasticity of housing wealth is higher than the corresponding elasticity with respect to financial assets, a finding similar with various studies (Barrell et al., 2015; Marquez et al., 2013; Carroll et al., 2011; Dreger and Reimers, 2012; Case et al., 2005; Catte et al., 2004; Ludwig and Slok, 2004; Barata and Pacheco, 2003). We also provide evidence that the consumption elasticity of household debt is statistically significant with a positive effect, indicating that households use part of their liabilities for consumption reasons in line with the empirical results of Kartashova and Tomlin (2017), Bunn and Rostom (2014) and Mian and Sufi (2016).

Second, we contribute to the existing literature on investigating the link of household financial wealth, household debt, housing wealth and private consumption expenditure in Greece, a country in which private consumption expenditure forms the largest and most stable component of GDP (almost 70%), and is well above the European average (almost 14 percentage points). Given its importance in shaping GDP, most of the fluctuation in Greek GDP can be traced to the impact of private consumption expenditures both in the pre-crisis and prost-crisis period. Moreover, Greece since 2010 has implemented a bold economic reform and adjustment programme that has eliminated flow macroeconomic imbalances. The cost of the adjustment programme in terms of output and unemployment losses has been immense, as output dropped by almost 25% and unemployment soared to 27.5%.

Moreover, important changes in the financial and housing markets marked the period covered in the present study. The liberalization of the Greek financial system matched with greater credit provisions along with the favourable macroeconomic conditions since 2000 resulted in many households becoming increasingly indebted, as households attempted to smooth their consumption through borrowing. During that time household wealth experienced a dynamic upward trend. Both housing and asset prices had been rapidly increasing rendering housing and financial market very attractive for investment. At the same time, the investment process in the housing market was greatly facilitated by the built-up of debt of the Greek households in an environment of low interest rates and easy access to credit (Manou and Papapetrou, 2016).

However, in the aftermath of the Greek economic crisis in late 2008 this positive outlook was reversed. Households were trapped in a cycle of slumping residential investment and contracting housing prices, over 45% between peak and trough. Still, fluctuation in the financial market due to heightened economic and political uncertainty, exerted downward pressure on financial asset prices and as a result financial disinvestment followed. In an environment of a substantial drop in output along with a dramatic increase in unemployment, high levels of non-performing loans were created (Louzis et al., 2012). The interaction of these factors had an extremely adverse effect on household wealth. In this context, a sharp need for deleveraging emerged and although so far a substantial balance sheet adjustment has taken place, the debt burden remains significant. The long lasting deleveraging pressure seems to have weighed on consumption growth and is expected to do so in the years to come.

Finally, our framework enables us to contribute to the existing literature by examining how consumption responds to large positive and negative household financial assets, household debt and housing wealth changes. Building on the previous stages we examine the short-term adjustment procedure by estimating asymmetric error-correction models, on the grounds that the variables under consideration are asymmetrically cointegrated. We allow the speed of a short-run adjustment process of actual consumption to its new target level to differ in the case of a positive shock in comparison to a negative one. We find evidence that consumption responds asymmetrically to all the types of changes applied. Our findings show that in the short run positive consumption discrepancies, following - negative wealth changes, persist for shorter periods, implying a faster speed of adjustment; that is we provide evidence for the predominance of negative changes compared to positive ones. Our empirical findings are consistent with a stronger consumption response to decreases in financial and housing wealth. Furthermore, our results add to the existing literature in that the driving force of the rapidly reducing consumption spending is the deleveraging process, a result similar to Mian et al., (2013), Mian and Sufi (2016), Bunn and Rostom (2014) and McCarthy and McQuinn (2017).

To our knowledge there is no previous work for a small open economy, like Greece to examine the response of consumption when wealth, financial and housing, and household debt change. The findings of our analysis might be indicative of other countries sharing similar economic characteristics like Greece, such as some Southern European counties and may contribute to the design and formulation of economic policies useful to long-term growth. The results are fundamental in explaining how changes in wealth components translate into economic changes and how policy should respond to these changes. Our results have an added policy relevance given the present distressed nature of the Greek economy and the fact that it is putting efforts to recover from the financial crisis/debt crisis.

The rest of the paper is organized as follows. Section 2 presents some stylized facts. Section 3 describes the econometric approach employed in the analysis and presents the data. Section 4 presents and discusses the empirical results obtained from the analysis and from the robustness investigation. Section 5 provides concluding remarks.

2. Some stylized facts

Before presenting the econometric methodology and results, an overview of the importance of consumption in shaping GDP developments in Greece is presented. The significant role of wealth effects on consumption is conveyed with an emphasis in the housing and the financial market along with household over-indebtedness in the run-up to the Greek economic crisis. The analysis also covers the period following the outbreak of the crisis when the economic outlook deteriorated amidst subsequent household effort to deleverage and with implications for consumption.

Private consumption plays a predominant role in Greece given its heavy weight on GDP which becomes even more substantial during the crisis years (Figure 1). More recently, in 2018q3, it accounted for 69% of GDP in real terms and is well above (almost 14 percentage points) the corresponding weight of the euro area. Given its importance in shaping GDP, most of the fluctuations in Greek GDP can be traced to the impact of private consumption both in the pre-crisis and prost-crisis period.

[Insert Figure 1 here]

Significant changes in the country's financial and housing market conditions from 2000 onwards may uncover a possible important role of wealth effects on private consumption in Greece (Manou and Papapetrou, 2016). In particular, drawing attention to household net wealth, measured as the excess of the value of total assets over total liabilities, it experienced a dynamic upward trend since 2002, reaching a peak in late 2007 representing an increase of 69%. As housing assets accounted for almost 76% of total household wealth throughout this period, the bulk of the aforementioned increase was attributed to the upward valuation of dwellings combined with buoyant housing investment activity and to a lesser degree to holding gains in the financial asset portfolio and financial investment. On the contrary, although the strong built-up of debt up to mid-2010 boosted housing investment, it acted as a drag on household net wealth. The outbreak of the Greek crisis in 2008 and its evolution over time had a detrimental effect on household net wealth which slump 36% between the end of 2007 and the third quarter of 2016 (peak and trough). Despite this marked decline, the composition of household wealth hasn't changed a lot with housing assets representing 72% of total household portfolio in the second quarter of 2018 (Figure 2).

[Insert Figure 2 here]

The interaction of housing and financial market developments along with household indebtedness behavior were the driving forces behind the pre-crisis accumulation of wealth and the increase in consumption. Focusing on the housing market, developments in residential investment and house prices can explain the most important part of wealth changes and associated wealth effects on consumption spending. These effects are quite important in the case of Greece, given its high homeownership ratio (around 74% in 2016) and the fact that Greek households considered property a safe asset and/or low-risk investment.

Economic theory unveils the relationship between consumption and housing wealth through the operation of a direct and an indirect channel (Case et al., 2013; Marquez et al., 2014). Related to real estate wealth, the direct channel implies that individuals may sell their houses and increase their consumption. Similarly, rising house prices may support consumption as households may feel wealthier, even though they have not sold their houses. Contrary, in response to falling housing prices, households may feel impoverished and decrease consumption. As a matter of fact, in the case of Greek households, changes in housing prices contributed by far the largest part to the overall change in housing wealth than housing investment. House price gains encouraged the consumption momentum of households mainly through the psychological dimension of the direct channel. As house prices went up, homeowners felt more confident and better off, even though their euphoria was not based on realized gains. This paved the way for lowering precautionary saving and boosting consumption. On the contrary, the indirect channel suggests that households can affect their consumption by borrowing against home equity (home equity lines of credit, home equity loans etc). However, prevailing credit market conditions are essential to interrelate consumption decisions to housing wealth changes. This mortgage equity withdrawal mechanism is more common to Anglo-Saxon countries compared to Southern European countries. The former countries have larger and more efficient mortgage markets that provide ample opportunities for taking cash out of homes. In the case of Greece, the latter channel, where remortgaging plays a significant role for boosting consumption, is extremely weak.

During the pre-crisis period (2002-2007) household housing investment[1], which consists mainly of dwellings and land increased from 16.2 billion euros (annualized data) or 10.5% of GDP in the first quarter of 2002 to 32.0 billion euros or 13.6% of GDP in the first quarter of 2008 (Figure 3). Housing turned to an attractive investment thanks to the pre-crisis favorable macroeconomic environment of supportive employment growth, low interest rates which combined with low credit standards, ensured the easy access to cheap loans and accelerating housing prices. Specifically, housing prices witnessed the remarkable increase of 99.2% in nominal terms, between the beginning of 2000 and the peak, which was reached in the third quarter of 2008. During the same period private consumption followed a similar pattern, supporting rising GDP growth rates.

[Insert Figure 3 here]

In late 2008 this positive outlook was reversed and as a result the housing market came under great pressure. Residential investment collapsed, amid increasing credit constraints and deteriorating labour market conditions, to reach 1.6 billion euros or 0.9% of GDP in the fourth quarter of 2015 before rebounding slightly more recently. This dramatic fall was quite synchronized with the plunge of housing prices (in nominal terms 41.0% between peak and the third quarter of 2018) (Figure 4). During that period consumption decreased severely.

[Insert Figure 4 here]

Greek households experienced a boom-bust cycle in the financial market as well (Figure 5). Before the outburst of the global financial crisis in 2007-2008, Greek households had been heavily investing in shares and other equity and to a lesser extent in debt securities in a search for attractive returns. However, deposits remained the preferred financial instrument for households throughout this period, representing steadily around 50% of their total financial wealth. Apart from the acquisitions of financial assets (transaction effect), households financial wealth had been growing mainly through increases in stock prices and to a lesser extent through upwards movements in bond prices (holding gains in the financial assets

[1] Household housing investment is defined as gross capital formation (gross fixed capital formation plus changes in inventories) plus acquisitions less disposals of non-produced assets. It includes acquisitions of housing, home improvements and capital goods acquired by self-employed business owners and non-profit institutions that serve households.

portfolio/valuation changes) reflecting strong corporate profitability and improving economic confidence about future economic growth.

[Insert Figure 5 here]

This picture changed markedly following the onset of the global financial crisis. As it began to take its toll on the Greek financial market, uncertainty and volatility increased sharply pushing the values of financial assets downwards and forcing households to shift to safer assets (such as deposits, currency holdings/hoarding and foreign mutual funds). Subsequently, amid mounting economic and political uncertainty and deteriorating macroeconomic conditions, households started to disinvest as of the second quarter of 2010 up to more recently. This combination of negative wealth effects and financial disinvestment had a severe downward impact on financial wealth. It is interesting to note that the positive adjustment in the value of financial assets in 2014 and again in 2017, although it boosted financial wealth, it failed to prevent the ongoing disinvestment.

The long housing boom of 2000-2007 was the overarching factor encouraging bank lending to increase, as house price increases facilitated to a great extent the availability of home-equity-based borrowing. Before the pre-crisis period, the increase in housing investment was in line with household build-up of debt mirroring optimistic expectations with regard to house price developments, a favorable macroeconomic environment of low interest rates and easy access to credit (Figure 6). As a result, the bulk of the loans of Greek households were mortgage loans (around 70% of total loans) while consumer loans accounted for 30%. This composition remains stable up to recent quarters.

[Insert Figure 6 here]

The interaction of the aforementioned factors resulted in households experiencing rising liabilities. Household indebtedness surged from 2002 and reached a peak in the third quarter of 2010, representing a 348% increase (partly due to a strong base effect from the low stock of liabilities in 2002). It is interesting to notice that Greek households continued to accumulate liabilities for two and a half years after the peak of residential investment had been reached. At the same time, households experienced a prominent surge in leverage measured as debt-to-income ratio, from a 32% in 2002 to a record of 110% in mid-2014.

Conversely, households failed to maintain momentum in residential investment when the credit crunch hit. Falling house prices discouraged building of new houses and coupled with rising interest rates added to a fall in bank lending. As the Greek crisis unfolded and with the implementation of economic adjustment programmes for Greece from 2010 onwards, households gradually began to reduce their net new debt incurrence. Furthermore the deleveraging process had also been taking place through write-downs/defaulting, a tendency which was more pronounced in the periods 2012-2014 and more recently, in 2017-2018. Although a substantial balance sheet adjustment has taken place so far, debt still remains elevated in comparison to pre-crisis levels. On the whole, household outstanding liabilities have fallen by 31% between peak and the third quarter of 2018. Besides, the considerable shrinkage of household disposable income during the crisis years acted as a significant headwind to the deleveraging process. Finally, as a consequence of the Greek crisis, the squeeze on disposable income, negative wealth effects and the deleveraging pressures resulted in the lacklustre performance of private consumption, being one of the main drivers of the recession in the country.

3. Econometric technique and data

To examine the time series dynamics between consumption, disposable income, financial assets, household debt and housing wealth, we frame our empirical strategy in three stages.

3.1.a Threshold cointegration analysis

Initially, to test for a long-run relationship between consumption spending, income and net worth components, namely financial assets, household debt and housing wealth, with possible asymmetric effects in the long-run relationship (Enders and Siklos, 2001; Stevans, 2004), the following long-run equilibrium relationship is estimated:

$$\ln cr_t = a_0 + a_1 \ln rdi_t + a_2 \ln asset_t + a_3 \ln liab_t + a_4 \ln hw_t + \varepsilon_t \quad (1)$$

where $\ln cr_t$ is the natural logarithm of consumption, $\ln rdi_t$ is the natural logarithm of disposable income, $\ln asset_t$ is the natural logarithm of financial assets, $\ln liab_t$ is the natural logarithm of financial liabilities and $\ln hw_t$ is the natural logarithm of housing wealth, a_i are the coefficients and ε_t is the error term.

Second, a two-regime threshold model is estimated, using the residuals from (2), as follows:

$$\Delta \hat{\varepsilon}_t = \rho_1 I_t \hat{\varepsilon}_{t-1} + \rho_2 (1 - I_t) \hat{\varepsilon}_{t-1} + \sum_{i=1}^{p} \varphi_i \Delta \hat{\varepsilon}_{t-1} + \mu_t \qquad (2)$$

where, $\rho_1, \rho_2, \varphi_i$ are coefficients to be estimated, *p* is the number of lags, $\mu_t \approx iid\left(0, \sigma_\varepsilon^2\right)$. The lag selection of *p* is specified using AIC and BIC tests. I_t is the Heaviside indicator:

$$I_t = \begin{cases} 1, \ln x_{i,t\text{-}1} \geq \tau \\ 0, \ln x_{i,t\text{-}1} < \tau \end{cases} \qquad (3.1)$$

$$I_t = \begin{cases} 1, \Delta \ln x_{i,t\text{-}1} \geq \tau \\ 0, \Delta \ln x_{i,t\text{-}1} < \tau \end{cases} \qquad (3.2)$$

where τ is the value of threshold, which can be endogenously determined using Chan's (1993) methodology. The Heaviside indicator can be specified with two different definitions of the threshold variable (τ), defining the Threshold Autoregression Model (TAR) model (eq. 3.1) and the Momentum Autoregression Model MTAR model (eq. 3.2), where $\ln x_{i,t\text{-}1}$, $\Delta \ln x_{i,t\text{-}1}$ are the threshold variables for the TAR and MTAR model respectively. In the specification i refers to financial assets $(\ln asset_t)$, household debt $(\ln liab_t)$ and housing wealth $(\ln hw_t)$ respectively. The values of the corresponding threshold variable are sorted in ascending order and the largest and smallest 15% of the values are discarded. The remaining 70% of the values are considered to be possible thresholds and the estimated threshold yielding the lowest residual sum of squares is the consistent estimate of the threshold parameter. Alternatively, the threshold value τ can be set equal to zero.

The TAR model captures asymmetric deep movements in the threshold variable, while MTAR can deal with steep variations in the threshold variable (Sun, 2011). As a result, TAR model allows examining the response of consumption in the positive (above threshold) and negative (below threshold) phase of the threshold variable, while MTAR model permits to examine the response of consumption to changes, namely positive (above threshold) and negative (below threshold) shocks in the threshold variable. In total, six models are estimated, specifically two models for each threshold variable. These are specified as follows: (a) consistent TAR, as in equation (3.1) and (b) consistent MTAR, as in equation (3.2). The threshold variable τ is estimated using Chan's (1993) methodology, for each of the three threshold variables and for each of the consistent TAR and MTAR models.

Having estimated the consistent TAR and MTAR models the validity of the long-run relationship (cointegration) among the variables is examined. The joint null hypothesis of no cointegration $\left(H_0 : \rho_1 = \rho_2 = 0\right)$ is tested against the alternative of cointegration according to Enders and Siklos (2001), Stevans (2004) and Sun (2011) using the Φ-statistic and the corresponding critical values. As the Φ-statistic does not follow the standard distribution, a Monte Carlo simulation to determine the correspoding critical values is applied (section 3.1.b). Rejection of the null hypothesis implies presence of threshold cointegration. Then, the null hypothesis of symmetric adjustment towards long-run equilibrium is evaluated $\left(H_0 : \rho_1 = \rho_2\right)$, using a standard F-test. Rejection of the null hypothesis implies that the adjustment process is asymmetric. If the null hypothesis is not rejected, then model (3) simplifies to:

$$\Delta \hat{\varepsilon}_t = \rho \hat{\varepsilon}_{t-1} + \sum_{i=1}^{p} \varphi_i \Delta \hat{\varepsilon}_{t-1} + \mu_t \tag{4}$$

Equation (4) coincides with the Engle and Granger (1987) specification, implying that the adjustment process towards long-run equilibrium is symmetric.

3.1.b Monte Carlo simulation

The test statistic, represented by Φ, for testing the null hypothesis of no cointegration $\left(H_0 : \rho_1 = \rho_2 = 0\right)$ is a non standard F-statistic as it does not follow the standard distribution (Enders and Siklos, 2001). As a result, to determine the critical values for testing the existence of threshold cointegration a Monte Carlo simulation is applied. Initially, the variables of the model, namely consumption, disposable income, financial assets, household debt and housing wealth are generated using random walk processes with 5000 trials, as follows:

$$\ln cr_t = \ln cr_{t-1} + u_{cr,t}\,, \quad u_{cr,t} \approx N(0,1) \tag{5.1}$$

$$\ln rdi_t = \ln rdi_{t\text{-}1} + u_{rdi,t}\,, \quad u_{rdi,t} \approx N(0,1) \tag{5.2}$$

$$\ln asset_t = \ln asset_{t\text{-}1} + u_{asset,t}\,, \quad u_{asset,t} \approx N(0,1) \tag{5.3}$$

$$\ln liab_t = \ln liab_{t\text{-}1} + u_{liab,t}\,, \quad u_{liab,t} \approx N(0,1) \tag{5.4}$$

$$\ln hw_t = \ln hw_{t\text{-}1} + u_{\ln hw,t}\,, \quad u_{hw,t} \approx N(0,1) \tag{5.5}$$

$t = 1, 2, ..., T$

At the next step, for each trial, the long-run relationship in Eq. (1) was estimated and the residuals were obtained to estimate Eq. (2). However, to estimate Eq. (2) the Heaviside indicators as in Eqs. (3.1) and (3.2) are used for consistent TAR (cTAR) and consistent MTAR (cMTAR) models, respectively. To determine the threshold values Chan's (1993) is applied methodology as follows: for each threshold variable, the possible threshold values are sorted in ascending order, for TAR and MTAR models respectively, and the top and bottom 15% were excluded to ensure that the model is identified for all thresholds. Then, for each possible threshold, Eq. (2) is estimated using the residuals from Eq. (1) and incorporating the Heaviside indicators for consistent TAR and consistent MTAR model respectively. The model with the lowest sum of squared errors yielded a consistent estimate of the threshold. For this model the nonstandard F-statistic, denoted by Φ, was recorded. This procedure is repeated for each of the three threshold variables and for the cTAR and cMTAR case for zero, one, two and three lags. The critical values of the nonstandard F-statistic generated above for $T = 76$ can be used to test the null hypothesis of no cointegration $\left(H_0 : \rho_1 = \rho_2 = 0\right)$ and are reported in Table 4.

3.1.c Asymmetric error-correction model with threshold cointegration

As a final step, asymmetric error-correction representations are developed to examine the short-run adjustment dynamics of consumption towards long-run equilibrium, for each threshold variable, as follows:

$$\Delta \ln cr_{asset,t} = \theta_{\ln asset} + \delta^{+}_{\ln asset} E^{+}_{t-1} + \delta^{-}_{\ln asset} E^{-}_{t-1} + \sum_{j=1}^{J} a_{\ln cr,j} \Delta \ln cr_{t-j} + \sum_{j=1}^{J} \beta_{\ln rdi,j} \Delta \ln rdi_{t-j}$$

$$+ \sum_{j=1}^{J} \gamma_{\ln asset,j} \Delta \ln asset_{t-j} + \sum_{j=1}^{J} \delta_{\ln liab,j} \Delta \ln liab_{t-j} + \sum_{j=1}^{J} \zeta_{\ln hw,j} \Delta \ln hw_{t-j} + u_{\ln asset,t} \quad (6.1)$$

$$\Delta \ln cr_{liab,t} = \theta_{\ln liab} + \delta^{+}_{\ln liab} E^{+}_{t-1} + \delta^{-}_{\ln liab} E^{-}_{t-1} + \sum_{j=1}^{J} a_{\ln cr,j} \Delta \ln cr_{t-j} + \sum_{j=1}^{J} \beta_{\ln rdi,j} \Delta \ln rdi_{t-j}$$

$$+ \sum_{j=1}^{J} \gamma_{\ln asset,j} \Delta \ln asset_{t-j} + \sum_{j=1}^{J} \delta_{\ln liab,j} \Delta \ln liab_{t-j} + \sum_{j=1}^{J} \zeta_{\ln hw,j} \Delta \ln hw_{t-j} + u_{\ln liab,t} \quad (6.2)$$

$$\Delta \ln cr_{hw,t} = \theta_{\ln hw} + \delta^{+}_{\ln hw} E^{+}_{t-1} + \delta^{-}_{\ln hw} E^{-}_{t-1} + \sum_{j=1}^{J} a_{\ln cr,j} \Delta \ln cr_{t-j} + \sum_{j=1}^{J} \beta_{\ln rdi,j} \Delta \ln rdi_{t-j}$$

$$+ \sum_{j=1}^{J} \gamma_{\ln asset,j} \Delta \ln asset_{t-j} + \sum_{j=1}^{J} \delta_{\ln liab,j} \Delta \ln liab_{t-j} + \sum_{j=1}^{J} \zeta_{\ln hw,j} \Delta \ln hw_{t-j} + u_{\ln hw,t} \quad (6.3)$$

where, $\Delta \ln cr_{asset,t}$, $\Delta \ln cr_{liab,t}$, $\Delta \ln cr_{hw,t}$ are the first differences of the natural logarithm of consumption, for each threshold variable, $\theta_{\ln asset}$, $\theta_{\ln liab}$, $\theta_{\ln hw}$ are the corresponding constants for each equation, $a_j, \beta_j, \gamma_j, \delta_j, \zeta_j$ are the coefficients of the lagged first differences, j represents the number of lags, u is the error term and E are the error-correction terms. The number of lags is chosen taking into account the Hannan–Quinn information criterion (HQIC) statistics and ensuring that the residuals have no serial correlation. The error-correction terms, $E^{+}_{t-1} = I_t \hat{\varepsilon}_{t-1}$ and $E^{-}_{t-1} = (1 - I_t) \hat{\varepsilon}_{t-1}$, are constructed from the threshold cointegration regressions in equations (2), (3.1), (3.2) and account for the asymmetric level of consumption in response to positive and negative shocks to deviations from the long-run equilibrium and also they consider the impact of threshold cointegration through the construction of the Heaviside indicators. $\Delta \ln cr_{t-j}$, $\Delta \ln rdi_{t-j}$, $\Delta \ln asset_{t-j}$, $\Delta \ln liab_{t-j}$, $\Delta \ln hw_{t-j}$ are the lagged variables in first difference.

3.2 Data

In the analysis quarterly data for Greece over the period from 1999Q4 to 2017Q4 are employed. Final consumption expenditure cr_t and disposable income rdi_t for households and non-profit institutions serving households (NPISH) are data from non-financial sector accounts of the Hellenic Statistical Authority (HSA). Financial wealth $asset_t$ is defined as currency and deposits, debt securities, equity, investment fund shares, insurance pension schemes and other accounts held by households and NPISH, household debt $liab_t$ is household financial liabilities and is defined as consumer loans, mortgage loans and other loans of households and NPISH. Data on household assets and household debt have been obtained from the financial accounts of the Bank of Greece. Housing wealth of households and NPISH hw_t is provided in annual frequency based on European Central Bank and Bank of Greece estimates up to 2012. Quarterly data are back-casted and interpolated using the cubic smoothing while from 2013 until 2017 housing wealth is adjusted using the annual percentage change of housing prices and the gross fixed capital formation of households. All variables are expressed in logarithmic format. To our knowledge it is the first time that data from financial accounts and balance sheets along with data from non-financial accounts are employed to uncover the linkages between the financial sector and the real economy in Greece.

4. Empirical results

Initially the stationarity properties of the series employed are examined. Two standard unit root tests, the Phillips and Perron (PP, 1988) and the Kwiatkowski, Phillips, Schmidt and Shin (KPSS, 1992), are performed. However, in the presence of structural breaks in the series this would possibly lead to false conclusions relative to the (non) stationarity of the series. To account for that, unit root tests that allow for the presence of structural breaks are utilized. Specifically, the Zivot and Andrews (1992) test was used to test for unit root allowing for one endogenously determined structural break while the Lagrange Multiplier (LM) unit root test by Lee and Strazicich (2013) was applied allowing for one or two possible structural breaks. The results provide evidence that the variables tested are integrated of order one I(1), allowing to conduct cointegration analysis (see Table in Appendix).

4.1 Long-term equilibrium relationship

We estimate the long-run equilibrium relationship (1) between consumption, disposable income, financial assets, financial liabilities and housing wealth using the Phillips-Hansen (1990) Fully Modified Ordinary Least Square (FMOLS) methodology, which corrects for possible endogeneity effects. Table 1 displays the estimated coefficients and the corresponding t-statistics.

[Insert Table 1 here]

Regression results show that all the variables in consideration are statistically significant and have a positive effect on consumption. Specifically, the elasticity of consumption with respect to disposable income is, as expected, the highest (0.589), implying that a 1 percent increase in disposable income is associated with a 0.589 percent increase in consumption. The elasticity of consumption with respect to financial assets (0.050) is lower than the corresponding elasticity of housing wealth (0.088), a finding in line with Barrell et al., (2015) and Marquez et al., (2013) with respect to UK, Carroll et al., (2011), Dreger and Reimers (2012), Case et al., (2005), Catte et al., (2004), Ludwig and Slok (2004), Barata and Pacheco (2003). Our findings contradict that of Marzabal and Menezes-Ferreira-Junior (2016) that report the predominance of the financial wealth over the housing wealth. A vital finding of the estimation is that the consumption elasticity of liabilities is statistically significant with a positive effect (0.086), indicating that the households use part of their liabilities for consumption reasons. This result is in line with Sousa (2008), who provides empirical support that consumption is sensitive to household debt. It also confirms the empirical results of Kartashova and Tomlin (2017) who find that a significant percent of homeowners' non-mortgage debt is used for non-housing consumption.

We also compute the marginal propensity to consume (MPC) out of each category of wealth and income. The findings are reported in Table 2. For comparison reasons we present the corresponding coefficient estimations, namely the estimated long-run elasticities of consumption.

[Insert Table 2 here]

Marginal propensities to consume results confirm the positive impact on consumption of disposable income, financial assets, household debt and housing wealth. The order of impact magnitude remains also unchanged compared to that of elasticities. The marginal propensity to consume with respect to disposable income is 0.573, suggesting that the effect on consumption of a 1 euro increase in disposable income is 0.573 euro. The corresponding marginal propensity to consume with respect to financial assets is 0.006, a finding similar to that of Sousa (2008) for directly held stock market wealth. The corresponding marginal propensities to consume for household debt and housing wealth are 0.028 and 0.003 respectively. The results point to a positive effect of household debt on consumption that is higher than the impact of financial assets and housing wealth. This finding is a strong indication that household debt plays a major role in financing household consumption spending and is in line with the findings of Mian et al., (2013), Burn and Rostom (2014) and Andersen et al., (2016) who find a significant role of debt in determining household spending. The positive relationship between household debt and consumption may also stem from the fact that financial liberalization motivated households, previously faced with liquidity constraints, to smooth consumption spending by using loans from the credit markets (Louzis et al., 2012). Similarly, Rodriguez-Palenzuela and Dees (2016) show that credit provided to households in Greece as in other stressed euro area countries, i.e. Ireland, Spain and Portugal was an important driver of consumption in the pre-crisis period.

4.2 Threshold cointegration results

Following Stevans (2004) the nonlinear cointegration analysis is performed using the threshold cointegration methodology. Possible asymmetric adjustment effects in consumption are examined using as threshold variables financial assets, financial liabilities and housing wealth for both consistent TAR and consistent MTAR models. The six threshold cointegration models presented in Table 3 are: the consistent TAR, using $\ln asset_{t-1}$ as threshold variable (column 2), the consistent MTAR, using $\Delta \ln asset_{t-1}$ as threshold variable (column 3), the consistent TAR, using

$\ln liab_{t\text{-}1}$ as threshold variable (column 4), the consistent MTAR using $\Delta \ln liab_{t\text{-}1}$ as threshold variable (column 5), the consistent TAR, using $\ln hw_{t\text{-}1}$ as threshold variable (column 6) and the consistent MTAR, using $\Delta \ln hw_{t\text{-}1}$ as threshold variable (column 7). To select the appropriate number of lags for each of the four models, initially a maximum of 3 lags is specified. Then diagnostic analysis on the residuals using AIC and BIC statistics is applied. The lag specifications with the lowest AIC and BIC values are selected and in all cases zero lag provides the lowest AIC and BIC values.

The threshold values τ for the consistent TAR and consistent MTAR models respectively are estimated according to Chan's (1993) methodology. For each of our models the threshold value with the lowest sum of squared errors is presented in the second row of Table 3. Thus, using financial assets, $\ln asset_{t\text{-}1}$, as a threshold variable, for the TAR model the threshold value with the lowest sum of squared errors (0.067) is 12.269, while for the MTAR model the corresponding threshold value, $\Delta \ln asset_{t\text{-}1}$, with the lowest sum of squared errors (0.066) is 0.033. Using financial liabilities as a threshold variable, for the TAR model the threshold value, $\ln liab_{t\text{-}1}$, with the lowest sum of squared errors (0.062) is 10.787, while for the MTAR model the corresponding threshold value, $\Delta \ln liab_{t\text{-}1}$, with the lowest sum of squared errors (0.063) is 0.051. Using housing wealth as a threshold variable, for the TAR model the threshold value, $\ln hw_{t\text{-}1}$, with the lowest sum of squared errors (0.062) is 13.428, while for the MTAR model the corresponding threshold value, $\Delta \ln hw_{t\text{-}1}$,with the lowest sum of squared errors (0.065) is 0.024.

[Insert Table 3 here]

Overall, for each different threshold variable the model, namely TAR or MTAR model, with the lowest AIC and BIC values, is chosen. For the case of the financial assets as threshold variable the consistent MTAR model has the lowest AIC (-309.900) and BIC (-305.265) statistics, for the case of the financial liabilities as a threshold variable the consistent TAR model has the lowest AIC (-315.249) and BIC (-310.614) statistics and, finally, for housing wealth as a threshold variable the consistent TAR model has the lowest AIC (-315.290) and BIC (-310.655) statistics.

As the Φ-Statistic for testing the null hypothesis of no cointegration $\left(H_0:\rho_1=\rho_2=0\right)$ does not follow the standard distribution we simulated the critical values, adjusted to our sample (T=76), using a Monte Carlo experimet generated with 5000 trials, as described in section 3.1.b. The critical values of the nonstandard F-statistic, denoted by Φ, are reported in Table 4.

[Insert Table 4 here]

For the case of financial assets as a threshold variable, $\Delta\ln asset_{t\text{-}1}$, the Φ-statistic $\left(H_0:\rho_1=\rho_2=0\right)$ for the consistent MTAR model has a value of 40.32, thus significant at 1% significance level, revealing that the null hypothesis of no threshold cointegration is rejected. Therefore, consumption, housing wealth, financial assets and household debt are cointegrated with threshold adjustment. The F-statistic, $\left(H_0:\rho_1=\rho_2\right)$ of the MTAR model has a value of 4.24 thus significant at 5% level, suggesting that the null hypothesis of symmetric adjustment is rejected. As a result when the variables are adjusting towards the long-run equilibrium, the adjustment process is asymmetric. The point estimate for the adjustment process is -0.527 for positive shocks, namely above threshold $\left(\Delta\ln asset_{t\text{-}1}\geq 0.033\right)$ and -1.113 for negative, specifically below threshold $\left(\Delta\ln asset_{t\text{-}1}<0.033\right)$ deviations from long-run equilibrium.

For household debt, $\ln liab_{t\text{-}1}$, as a threshold variable the Φ-statistic $\left(H_0:\rho_1=\rho_2=0\right)$ for the consistent MTAR model is 46.00, significant at 1% significance level, showing that the null hypothesis of no threshold cointegration is rejected. The F-statistic $\left(H_0:\rho_1=\rho_2\right)$ of the TAR model is 9.95, significant at 1% level, and the the null hypothesis of symmetric adjustment is rejected. As a result when the variables are adjusting towards the long-run equilibrium, the adjustment process is asymmetric. The point estimate for the adjustment process is -0.790 for positive shocks, that is above threshold $\left(\ln liab_{t\text{-}1}\geq 10.787\right)$ and -1.581 for negative, namely below threshold $\left(\ln liab_{t\text{-}1}<10.787\right)$ deviations from long-run equilibrium.

Finally, when housing wealth is treated as the threshold variable, $\ln hw_{t\text{-}1}$, the Φ-statistic $\left(H_0 : \rho_1 = \rho_2 = 0\right)$ for the consistent MTAR model, has a value of 46.05, significant at 1% significance level. This suggests that the null hypothesis of no threshold cointegration is rejected and there is evidence that consumption, housing wealth, financial assets and household debt are cointegrated with threshold adjustment. The F-statistic $\left(H_0 : \rho_1 = \rho_2\right)$ of the TAR model has a value of 9.99, significant at 1% level, revealing that the null hypothesis of symmetric adjustment is rejected. When the variables are adjusting towards the long-run equilibrium, the adjustment process is asymmetric and quicker adjustment to negative shocks than to positive shocks is revealed. In particular, the point estimate for the adjustment process is -0.796 for positive shocks, specifically above threshold $\left(\ln hw_{t\text{-}1} \geq 13.428\right)$ and -1.602 for negative, explicitly below threshold $\left(\ln hw_{t\text{-}1} < 13.428\right)$ deviations from long-run equilibrium.

According to Enders and Siklos (2001) Φ-statistic is used only in those cases in which the point estimates for ρ_1, ρ_2 imply convergence. The necessary conditions for convergence suggest for the point estimates ρ_1, ρ_2 to be negative. Furthermore, according to Petrucelli and Woolford (1984) the necessary and sufficient conditions for cointegration are that the point estimates ρ_1, ρ_2 to be negative and moreover $\left(1+\rho_1\right)\left(1+\rho_2\right) < 1$[2]. The point estimates of all our three consistent TAR, MTAR models satisfly both conditions, thus implying convergence. Overall, the threshold cointegration analysis reveals that in the long term, the adjustment takes place quicker when the corresponding threshold variable, namely financial assets, financial liabilities or housing wealth decrease or increase below the estimated threshold, namely for negative deviations.

---

[2] According to Enders and Chumrusphonlert (2004) a sufficient condition for $\hat{\varepsilon}_t$ sequence to be stationarity is $-2 < \rho_1, \rho_2 < 0$. If convergence of $\hat{\varepsilon}_t$ is sufficiently large, it is also possible for one value of ρ_i to lie between -2 and 0 and for the other value to be equal to zero.

4.3 Short-term consumption response

Next, we estimate three asymmetric error-correction models that incorporate the impact of threshold cointegration through the development of the Heaviside Indicator using equations (3.1) and (3.2). A lag of four is selected for the models based on diagnostic analyses on the residuals with HQIC statistics. The estimation results of the asymmetric error-correction models are reported in Table 5.

The point estimates of the ECM's coefficients for the case of financial assets as a threshold variable are 0.174, when financial assets increase by more than the estimated threshold $\left(\Delta \ln asset_{t\text{-}1} \geq 0.033\right)$ and -0.754 when financial assets decrease or increase less than the estimated threshold $\left(\Delta \ln asset_{t\text{-}1} < 0.033\right)$. However, as only the ECM coefficient for negative shocks is statistically significant (1% level) the short-term adjustment process of consumption occurs only for negative deviations from long-run equilibrium. Specifically, when financial assets decrease or increase less than the estimated threshold, a positive 1% consumption error in the previous period leads to a 0.754% decrease in consumption growth rate and the corresponding deviations from long-run equilibrium are eliminated at a rate of 75.4% quarterly. This evidence suggests that in the short-run negative deviations take about 1.32 quarters to be fully absorbed. On the contrary, when financial assets increase more than the estimated threshold the ECM's coefficient is not statistically significant, thus implying the absence of adjustment path. These results are in line with Marquez et al., (2013) who finds a stronger consumption response to financial wealth decreases in UK, Donihue and Avramenko (2007) who find similar results for United States and Apergis and Miller (2006) that support the hypothesis that bad-news financial shocks have a 50% higher peak effect than good ones on real per capita consumption. This asymmetric impact can be interpreted according to the assumption of diminishing marginal utility of wealth, implying that consumers are risk averse. Another possible explanation is the notion of 'negativity bias' introduced by Nguyen and Claus (2013). According to their empirical findings, bias in household feelings towards an event leads them to respond more intense in negative than positive financial asset shocks. Finally, liquidity and credit constraints implying difficulties in borrowing in order to strengthen consumption during fall in financial asset values could also explain the predominance of negative shocks compared to positive ones. On the contrary, in countries with developed financial institutions, assets can be easily sold providing liquidity to support consumption spending (Cooper and Dynan, 2016). Thus, in the context of a developed financial sector with easy access to credit, a negative wealth shock would be expected to lead to a weaker consumption effect (MacDonald et al., 2011).

The point estimates of the ECM's coefficients for financial liabilities as a threshold (shock) variable are -0.585, when financial liabilities increase by more than the estimated threshold $\left(\ln liab_{t\text{-}1} \geq 10.787\right)$ and -0.871 when financial liabilities decrease or increase less than the estimated threshold $\left(\ln liab_{t\text{-}1} < 10.787\right)$. Both of the ECM's coefficients are statistically significant at 1% and 5% level respectively, implying that the short-term adjustment path occurs through consumption not only for positive (above threshold) but also for negative (below threshold) financial liabilities shocks. When household debt increase by more than the estimated threshold, a negative 1% consumption error in the previous error leads to a 0.585% increase in the consumption growth rate, while when household debt decrease (deleveraging shock) or increase less than the estimated threshold, a positive 1% consumption error in the previous error leads to a 0.871% decrease in the consumption growth rate. This evidence suggests that positive deviations take about 1.71 quarters to be fully absorbed, while negative deviations take about 1.14 quarters to be fully eliminated.

Overall, our error-correction model analysis reveals that there is a substantial faster convergence for the case of a deleveraging shock, a finding that confirms the role of leverage in leading to consumption driven recessions, as in Mian et al., (2013) across the United States during the Great Recession and also over longer time horizons as Mian and Sufi (2016) conclude. It also provides evidence in favor of the debt driven slump assumption made by Eggertsson and Krugman (2012), according to which highly indebted households that are forced to a sharp deleverage rapidly reduce their aggregate demand. Furthermore, our results add to the existing literature in that the driving force of the rapidly reducing consumption spending is the deleveraging shock.

The point estimates of the ECM's coefficients for the case of housing wealth as a threshold variable are -0.336, when housing wealth increases by more than the estimated threshold $(\ln hw_{t\text{-}1} \geq 13.428)$ and -0.855 when housing wealth decreases or increases less than the estimated threshold $(\ln hw_{t\text{-}1} < 13.428)$. Both of the ECM's coefficients are statistically significant at 10% and 5% level respectively, implying that the short-term adjustment path occurs through consumption not only for positive (above threshold) but also for negative (below threshold) deviations. When housing wealth increases by more than the threshold, a negative 1% consumption error in the previous error leads to a 0.336% increase in the consumption growth rate. When housing wealth decreases or increases by less than the estimated threshold, a positive 1% consumption error in the previous error leads to a 0.855% decrease in the consumption growth rate. This evidence suggests that deviations above threshold take about 2.97 quarters to be fully absorbed, while deviations below threshold take about 1.17 quarters, implying that the corresponding deviations are eliminated at a rate of 33.6% and 85.5% quarterly, respectively. Negative housing wealth shocks usually coincide with weak income developments leading to increased uncertainty, fall in real estate investment, debt payment problems and bank restrictions in credit supply, thus creating disproportionate reactions and reinforcing income losses (ECB, 2009). As a result, a negative housing wealth shock would be expected to lead to a faster consumption adjustment towards a lower level of equilibrium due to these combined effects in comparison to a positive housing wealth shock. These reactions may be even more extreme and disproportionate in cases like Greece, where households consider housing wealth to be the most important component of their wealth. Our results provide strong evidence in support of this argument as the household reaction to a negative housing wealth shock is more than double compared to the reaction following a positive shock. A weaker consumption effect in the case of a positive housing wealth shock can be explained by the very limited use of the Housing Equity Withdrawal (HEW) mechanism in the Greek real estate market, which eventually restricts the ability of taking cash out of homes. In the case of a positive housing wealth shock, this mechanism could either allow households to extract equity from their housing wealth or even lower their savings, thus increasing consumption, as it plays the role of a safety wealth net against negative future income shocks (Gan, 2010). In either case, the response of consumption to a positive housing wealth shock would be stronger than to a negative one. Another possible explanation is that Greek households have already discounted the upward trend of housing wealth in their consumption behavior and thus only negative shocks may have an effect on their spending decisions as in Marquez et al., (2014) for the US economy. The quality of financial institutions could provide an additional explanation. Strong financial institutions would provide the homeowners liquidity to finance consumption spending against the value of their housing collaterals. However, the Greek economy is characterized by a high level of non-performing loans combined with a fall in home prices. This situation reduces the ability of the financial system to provide the necessary liquidity, thus adding to the intense fall of consumption.

[Insert Table 5 here]

4.4 Robustness analysis

Having validated the hypothesis of threshold cointegration, we now examine the robustness of the asymmetric relationship between consumption and net wealth components by introducing an alternative continuous threshold model methodology, initially developed by Chan and Tsay (1998) and further developed by Hansen (2017). Continuous threshold model methodology allows searching for an induced kink in depicting the relationship between the assignment variable and the outcome variable that coincides with the kink in the policy rule (Card et al., 2012). A regression kink model, contrary to the TAR and MTAR methodology, is a threshold regression constrained to be everywhere continuous.

Following Hansen (2017), we establish three regression kink models, one for each net wealth component, as follows:

$$\ln cr_t = \beta_1 \left(\ln asset_t - \gamma\right)_- + \beta_2 \left(\ln asset_t - \gamma\right)_+ + \beta_3^{'} z_{\ln asset,t} + e_t \quad (7)$$

$$\ln cr_t = \beta_1 \left(\ln liab_t - \gamma\right)_- + \beta_2 \left(\ln liab_t - \gamma\right)_+ + \beta_3^{'} z_{\ln liab,t} + e_t \quad (8)$$

$$\ln cr_t = \beta_1 (\ln hw_t - \gamma)_- + \beta_2 (\ln hw_t - \gamma)_+ + \beta_3^{'} z_{\ln hw,t} + e_t \qquad (9)$$

where $\ln cr_t$, $\ln asset_t$, $\ln liab_t$, $\ln hw_t$ are scalars denoting observable variables corresponding to the natural logarithm of consumption, the natural logarithm of financial assets, the natural logarithm of financial liabilities and the natural logarithm of housing wealth, respectively. e_t is also a scalar denoting the error term, while the observable variable z_t is an $l-$vector that includes an intercept. It holds that $z_t = (\ln cr_{t-1} 1)^{'}$ in order for the error term to be serially uncorrelated. $\beta_1, \beta_2, \beta_3$ are the regression slopes denoting coefficients to be estimated and γ is the unknown threshold parameter known as "kink point". We use $(\ln x_{i,t} - \gamma)_- = \min[\ln x_{i,t} - \gamma, 0]$ and $(\ln x_{i,t} - \gamma)_+ = \max[\ln x_{i,t} - \gamma, 0]$ to denote the negative and positive part of the respective difference, where $x_{i,t}$ denotes the assignment variable for each of the three net wealth components, i, where i refers to financial assets, financial liabilities and housing wealth respectively. It is straightforward to mention that the kink models developed above hold only under the assumption that the threshold is in the interior of the support of each threshold variable $x_{i,t}$, thus implying that γ ε Γ, where Γ is compact and strictly in the interior of the support of each threshold variable $x_{i,t}$.

To determine the threshold for each of our three net wealth variables the least square criterion is applied:

$$S_n(\beta, \gamma) = \frac{1}{n} \sum_{t=1}^{n} \left(\ln cr_t - \beta^{'} x_{i,t}(\gamma) \right)^2$$

The corresponding least square estimator $\left(\hat{\beta}, \hat{\gamma} \right)$ is the joint minimizer of $S_n(\beta, \gamma)$.

It holds that: $\left(\hat{\beta}, \hat{\gamma} \right) = \underset{\beta \varepsilon R^{k-1}, \gamma \varepsilon \Gamma}{\arg\min} S_n(\beta, \gamma)$

where, $S_n(\beta, \gamma)$ is quadratic in β but nonconvex in γ.

Therefore we have:

$$\hat{\gamma} = \underset{\gamma \varepsilon \Gamma}{\arg\min} \min_{\beta \varepsilon R^{k-1}} S_n(\beta, \gamma) = \underset{\gamma \varepsilon \Gamma}{\arg\min} S_n^{*}(\beta, \gamma)$$

As a result the least square criterion can be expressed as the concentrated sum-of-squared errors, as:

$$S_n^*(\gamma) = S_n\left(\hat{\beta}(\gamma), \gamma\right) = \frac{1}{n}\sum_{t=1}^{n}\left(\ln cr_t - \hat{\beta}(\gamma)' x_{i,t}(\gamma)\right)^2$$

where, $\hat{\beta}(\gamma)$ are the least square coefficients from standard regression of $\ln cr_t$ on each of the threshold variables $x_{i,t}(\gamma)$ and,

$$x_{i,t}(\gamma) = \begin{pmatrix} (x_{i,t} - \gamma)_- \\ (x_{i,t} - \gamma)_+ \\ z_{i,t} \end{pmatrix} \quad \text{for } i = \ln asset_t, \ln liab_t, \ln hw_t$$

To determine the value of the threshold, γ, for each of the wealth components a grid search is applied. At each gridpoint the least square coefficients are estimated, and then the least square criterion $S_n^*(\gamma)$ is computed. The value that minimizes the least square criterion is chosen as threshold. Once the threshold $\hat{\gamma}$ is estimated, we find the least square coefficients from the standard regression of $\ln cr_t$ on each of the threshold variables $x_{i,t}\left(\hat{\gamma}\right)$, for $i = \ln asset_t, \ln liab_t, \ln hw_t$. Figure 7 depicts the evolution of the concentrated least square criterion values in relation with the threshold parameter.

[Insert Figure 7 here]

Table 6 presents the 90% confidence intervals for the slope coefficients and the threshold parameter estimated for each of the three kink models. The confidence intervals are computed applying Hansen's (2017) symmetric percentile bootstrap methodology for the slope coefficients and the test inversion confidence intervals methodology for the threshold parameters, using 10.000 bootstrap replications. For each of the three kink models the threshold value with the lowest least square criterion is presented in the first row of Table 6. Specifically, for minimizing the least square criterion $S_n^*(\gamma)$ of the first kink model a discrete grid search with increments 0.001 that corresponds to 581 gridpoints is applied. The least square criterion is minimized when the threshold parameter takes the value $\hat{\gamma}_{\ln asset} = 12.492$. The estimated threshold parameters for the second and the third kink model are $\hat{\gamma}_{\ln liab} = 11.510$, with 801 gridpoints and $\hat{\gamma}_{\ln hw} = 13.810$ with 191 gridpoints respectively. Even if we have to take into consideration the limitations of the bootstrap methodology relative to the time series nature of the data the point estimates for all three kink models are consistent with the hypothesis of an asymmetric behavior of consumption as the slope with respect to each net wealth component is discontinuous at the estimated threshold point (Hansen, 2017; Hidalgo et al., 2019). Specifically, for the first kink model the slope with respect to financial assets equals -0.053 for values of financial assets less than the estimated value 12.492 and equals 0.180 for values greater than the threshold value. For the second kink model, the slope with respect to financial liabilities is 0.023 and -0.058 for values of financial liabilities less and greater than the estimated threshold value, respectively. For the last kink model, the slope with respect to housing wealth is 0.440 and 1.19 for values of housing wealth less and greater than the estimated threshold value, respectively. Overall, the robustness analysis clearly shows that by applying kink regression model analysis, consumption and net wealth components time series data in the case of Greece fit better to threshold models than to linear models. At the same time, the analysis shows that we have strong indications to support the argument that the impact of wealth components to consumption results in a dual dimension asymmetry.

[Insert Table 6 here]

5. Conclusions and policy implications

The present study examines the asymmetric transmission effects of financial assets, financial liabilities and housing wealth on consumption spending for Greece over the period 1999Q4 to 2017Q4. The analysis studies the asymmetric linkages by applying threshold autoregressive methodology developed by Enders and Siklos (2001) and Stevans (2004).

Employing financial assets, financial liabilities and housing wealth as threshold variables there is evidence of multiple asymmetric effects on consumption. The elasticity of housing wealth is higher than the corresponding elasticity with respect to financial assets. We also provide evidence that the consumption elasticity of household debt is statistically significant with a positive effect, indicating that households use part of their liabilities for consumption reasons.

Furthermore, our statistical framework enables us to contribute to the existing literature by examining consumption responses to large positive and negative household net wealth changes. We examine the short-term adjustment procedure by estimating asymmetric error-correction models, on the grounds that the variables under consideration are asymmetrically cointegrated. We allow the speed of a short-run adjustment process of actual consumption to its new target level to differ in the case of a positive wealth change in comparison to a negative one. Overall, the results of the asymmetric ECM models on the short-term speed of adjustment confirm the findings of the TAR and MTAR models on the long-run speed of adjustment, as in both cases the speed of adjustment for negative deviations is faster than for positive deviations. Our results show that consumption responds asymmetrically to all types of wealth shocks applied. Evidence for the predominance of negative shocks compared to positive ones is provided. Our empirical findings are consistent with a stronger consumption response to decreases in financial wealth and housing wealth. Furthermore, our results add to the existing literature in that the driving force of the rapidly reducing consumption spending is deleveraging. In addition, we document that the speed of adjustment of consumption for a positive housing wealth change is more than double than the corresponding speed of adjustment for a negative household debt change (deleverage).

We also checked the robustness of our results by applying the kink regression model analysis, a continuous regime changing model. The empirical results of both methodologies provide strong evidence that consumption and net wealth components time series data in Greece fit better to threshold models than to linear models. Further, we have indications to support the argument that the impact of net wealth components to consumption results in a dual dimension asymmetry.

Overall, we have identified that besides disposable income, financial assets, housing wealth as well as outstanding household debt are significant drivers of consumption behavior. In addition we have documented that the adjustment of consumption is faster during deleverage periods. All in all, our empirical analysis has established a more solid understanding of consumer behavior related not only to financial assets and housing wealth but also to indebtedness and has contributed towards a profounder understanding of the linkages between the financial markets and the real economy.

References

Afonso, A., and Sousa, R.M. (2011) What are the effects of fiscal policy on asset markets?. *Economic Modelling*, *28*(4): 1871-1890.

Andersen, A.L., Duus, C., and Jensen, T.L. (2016) Household debt and spending during the financial crisis: Evidence from Danish micro data. *European Economic Review*, *89:* 96-115.

Ando, A., and Modigliani, F. (1963) The "life cycle" hypothesis of saving: aggregate implications and tests. *The American Economic Review*, *53*(1): 55-84.

Apergis, N., and Miller, S.M. (2006) Consumption asymmetry and the stock market: empirical evidence. *Economic Letters,* 93(3): 337-342.

Arrondel, L., Lamarche, P., and Savignac, F. (2019) Does inequality matter for the consumption-wealth channel? empirical evidence. *European Economic Review*, *111:* 139-165.

Baker, S.R. (2014) Debt and the consumption response to household income shocks: validation and application of linked financial account data. *Journal of Political Economy*, 126(4): 1504-1557.

Barata, J.M., and Pacheco, L.M. (2003) Asset prices and monetary policy: wealth effects on consumption. Paper presented at the *20th Symposium on Banking and Monetary Economics*, Birmingham.

Barell, R. Costantini, M., and Meco, I. (2015) Housing wealth, financial wealth, and consumption: new evidence for Italy and UK. *International Review of Financial Analysis,* 42: 316-323.

Bunn, P., and Rostom, M. (2014) Household debt and spending. *Bank of England Quarterly Bulletin*, 54(3): 304-315.

Card, D., Lee, D., Pei, Z., and Weber, A. (2012) Nonlinear policy rules and the identification and estimation of causal effects in a generalized regression kink design (No. w18564). *National Bureau of Economic Research*.

Carroll, C.D., Otsuka, M. and Slacalek, J. (2011) How large are housing and financial effects? A new approach. *Journal of Money, Credit and Banking,* 43: 55-79.

Case, K.E., Quigley, J.M. and Shiller, R.J. (2005) Comparing wealth effects: the stock market versus the housing market. *The B.E Journal of Macroeconomics Advances in Macroeconomics,* 5(1): 1-32.

Case, K. E., Quigley, J. M. and Shiller, R.J. (2013) Wealth effects revisited: 1975-2009. Working Paper, *National Bureau of Economic Research*, No.18667.

Catte, P., Girouard, N., Price, R.W., and André, C. (2004) Housing markets, wealth and the business cycle, OECD, 394.

Chan, K.S. (1993) Consistency and limiting distribution of the least squares estimator of a threshold autoregressive model. *The Annals of Statistics*, 21(1): 520-533.

Chan, K.S., and Tsay, R.S. (1998) Limiting properties of the least squares estimator of a continuous threshold autoregressive model. *Biometrika*, *85*(2): 413-426.

Cooper, D., and Dynan, K. (2016) Wealth effects and macroeconomic dynamics. *Journal of Economic Surveys,* 30(1): 34-55.

De Bonis, R., and Silvestrini, A. (2012) The effects of financial and real wealth on consumption: new evidence from OECD countries. *Applied Financial Economics*, *22*(5): 409-425.

Donihue, M., and Avramenko, A. (2007) Decomposing consumer wealth effects: evidence on the role of real estate assets following the wealth cycle of 1990-2002. *The B.E. Journal of Macroeconomics,* 7: article 25.

Dreger, C., and Reimers, H.H. (2012) The long run relationship between private consumption and wealth: common and idiosyncratic effects. *Portuguese Economic Journal,* 11(1): 21-34.

Dynan, K. (2012) Is a household debt overhang holding back consumption?. *Brookings Papers on Economic Activity*, 299-344.

Eggertsson, B.E., and Krugman, P. (2012) Debt, develeraging and the liquidity trap: a Fisher-Minsky-Koo Approach. *The Quarterly Journal of Economics,* 127: 1469-1513.

Enders, W. and Siklos, P.L. (2001) Cointegration and threshold adjustment. *Journal of Business and Economic Statistics,* 19(2): 166-176.

Enders, W., and Chumrusphonlert, K. (2004) Threshold cointegration and purchasing power parity in the pacific nations. *Applied Economics*, *36*(9): 889-896.

Engle, R.F., and Granger, C.W. (1987) Co-integration and error correction: representation, estimation and testing. *Econometrica: Journal of the Econometric Society,* 251-276.

European Central Bank (ECB) (2009) Housing finance in the euro area, Occasional Paper Series, No 101, March.

Friedman, M. (1957) *A theory of the consumption function*. Princeton University Press, 1-6.

Gan, J. (2010) Housing wealth and consumption growth: evidence from a large panel of households. *Review of Financial Studies,* 23(6): 2229-2267.

Hansen, B.E. (2017) Regression kink with an unknown threshold. *Journal of Business and Economic Statistics*, *35*(2), 228-240.

Hidalgo, J., Lee, J., and Seo, M.H. (2019) Robust inference for threshold regression models. *Journal of Econometrics*, 210(2): 291-309.

Kartashova, K., and Tomlin, B. (2017) House prices, consumption and the role of non-mortage debt. *Journal of Banking and Finance,* 28: 121-134.

Kichian, M., and Mihic, M. (2018) How important are wealth effects on consumption in Canada?. *Canadian Journal of Economics/Revue Canadienne d'Economique*, *51*(3): 784-798.

Kwiatkowski, D., Phillips, P.C.B., Schmidt, P., and Shin, Y. (1992) Testing the null hypothesis of stationarity against the alternative of a unit root. *Journal of Econometrics,* 54(1-3): 159-178.

Lee, J., and Strazicich, M.C. (2013) Minimum LM unit root test with one structural break. *Economics Bulletin*, 33(4): 2483-2492.

Louzis, D.P., Vouldis, A.T., and Metaxas, V.L. (2012) Macroeconomic and bank-specific determinants of non-performing loans in Greece: a comparative study of mortgage, business and consumer loan portfolios. *Journal of Banking and Finance*, 36(4): 1012-1027.

Ludwig, A., and Sløk, T. (2004) The relationship between stock prices, house prices and consumption in OECD countries. *Topics in Macroeconomics,* 4(1): 1-26.

MacDonald, G., Mullineux, A. and Sensarma, R. (2011) Asymmetric effects of interest rate changes: the role of the consumption-wealth channel. *Applied Economics* 43(16): 1991-2001.

Manou, K., and Papapetrou, E. (2016) The economic behaviour of households in Greece: recent developments and prospects. *Economic Bulletin*, Bank of Greece (44): 7-33.

Marquez, E., Martinez-Canete A.R., and Perez-Soba, I. (2013) Wealth shocks, credit conditions and asymmetric consumption response: empirical evidence for the UK. *Economic Modelling,* 33: 357-366.

Marquez, E., Martinez-Canete A.R., and Perez-Soba, I. (2014) From real estate to consumption: the role of credit markets in the USA. *Applied Economics,* 46(16-18): 2178-2189.

Marzabal, O.R., and Menezes-Ferreira-Junior, V. (2016) The wealth effect in the Eurozone. *Panoeconomics* 63(1): 87-112.

McCarthy, Y., and McQuinn, K. (2017) Deleveraging in a highly indebted property market: who does it and are there implications for household consumption?. *Review of Income and Wealth*, *63*(1): 95-117.

Mian, A., Rao, K., and Sufi, A. (2013) Household balance sheets, consumption and the economic slump. *The Quarterly Journal of Economics,* 128(4): 1687-1726.

Mian, A., and Sufi, A. (2014) What explains the 2007–2009 drop in employment?. *Econometrica*, *82*(6): 2197-2223.

Mian, A., and Sufi, A. (2016) Who bears the cost of recessions? The role of house prices and household debt. In *Handbook of Macroeconomics,* 2: pp. 255-296. Elsevier.

Mian, A., Sufi, A., and Verner, E. (2017) Household debt and business cycles worldwide. The Quarterly Journal of Economics, 132(4): 1755-1817.

Navarro, M. L., and de Frutos, R.F. (2015) Residential versus financial wealth effects on consumption from a shock in interest rates. *Economic Modelling*, *49:* 81-90.

Nguyen, V.H., and Claus, E. (2013) Good news, bad news, consumer sentiment and consumption behavior. *Journal of Economic Psychology,* 39: 426-438.

Petrucelli, J., and Woolford, S. (1984) A Threshold AR(1) model. *Journal of Applied Probability*, 21:270-286.

Phillips, P.C., and Hansen, B.E. (1990) Statistical inference in instrumental variables regression with I (1) processes. *The Review of Economic Studies*, *57*(1): 99-125.

Phillips, P.C.B., and Perron, P. (1988) Testing for a unit root in time series regression. *Biometrika,* 75(2): 335-346.

Poterba, J.M. (2000) Stock market wealth and consumption. *Journal of Economic Perspectives*, 14(2): 99-118.

Rodriguez-Palenzuela, D., and Dees, S. (2016) Savings and investment behaviour in the euro area, *European Central Bank*, Occasional Paper Series, No. 167.

Sierminska, E., and Takhtamanova, Y. (2012) Financial and housing wealth and consumption spending: cross-country and age group comparisons. *Housing Studies*, 27(5): 685-719.

Sousa, R.M. (2008) Financial wealth, housing wealth and consumption. *International Research Journal of Finance and Economics,* 19: 167-191.

Stevans, L.K. (2004) Aggregate consumption spending, the stock market and asymmetric error correction. *Quantitative Finance,* 4(2): 191-198.

Sun, C. (2011) Price dynamics in the import wooden bed market of the United States. *Forest Policy and Economics,* 13(6): 479-487.

Zivot, E., and Andrews, D.W.K. (1992) Further evidence on the Great Crash, the oil-price shock, and the unit-root hypothesis. *Journal of Business and Economic Statistics,* 10(3): 251-270.

Appendix

Table: Unit root tests

	ln *cr*		ln *rdi*		ln *asset*		ln *liab*		ln *hw*	
	Level	First Difference	Level	First Difference	Level	First Difference	Level	First Difference	Level	First Difference
Part A: Unit root test not allowing for structural breaks										
KPSS	0.251***	0.102	0.249***	0.139	0.134*	0.055	19.190***	0.096	0.258***	0.108
P.Perron	-2.381 [8]	-85.597 [7]***	-2.830 [8]	-93.195 [11]***	-2.675 [5]	-7.988 [1]***	-0.871 [11]	-80.483 [8]***	-3.118 [11]	-4.391***
Part B: Unit root tests allowing for structural breaks										
Zivot-Andrews (1 break)	-3.542[4]	-6.431[3]***	-3.419[4]	-5.210[4]**	-3.433[3]	-7.436[4]***	-3.476[3]	-8.169[2]***	-3.848[4]	-9.101[1]***
Breakpoint	2006Q4	2010Q2	2006Q3	2010Q2	2009Q4	2007Q3	2007Q2	2008Q4	2007Q3	2011Q2
Lee and Strazicich (1 break)	-3.044 [4]	-5.713[4]***	-3.247 [4]	-7.952 [3]***	-3.557 [3]	-4.522 [2]**	-2.795[4]	-9.218[1]***	-3.280[4]	-4.353[2]**
Breakpoint	2010Q1	2015Q3	2010Q1	2009Q1	2006Q1	2003Q1	2012Q1	2003Q4	2008Q2	2008Q2
Lee and Strazicich (2 breaks)	-5.427 [4]	-8.620 [4]***	-5.609 [4]	-8.677 [3]***	-3.754 [3]	-10.925 [1]***	-4.125 [2]	-9.705 [3]***	-3.623 [3]	-10.204 [1]***
Breakpoints	2008Q4 2012Q1	2008Q3 2015Q4	2008Q1 2013Q1	2002Q1 2007Q2	2005Q1 2011Q1	2000Q4 2007Q1	2005Q4 2011Q1	2004Q1 2010Q2	2007Q3 2009Q2	2007Q3 2012Q1

Notes: The numbers in the bracket are lags used in the test. The lag order of the PP, LM , ZA test is in accordance with the AIC and t-stat. lag length.

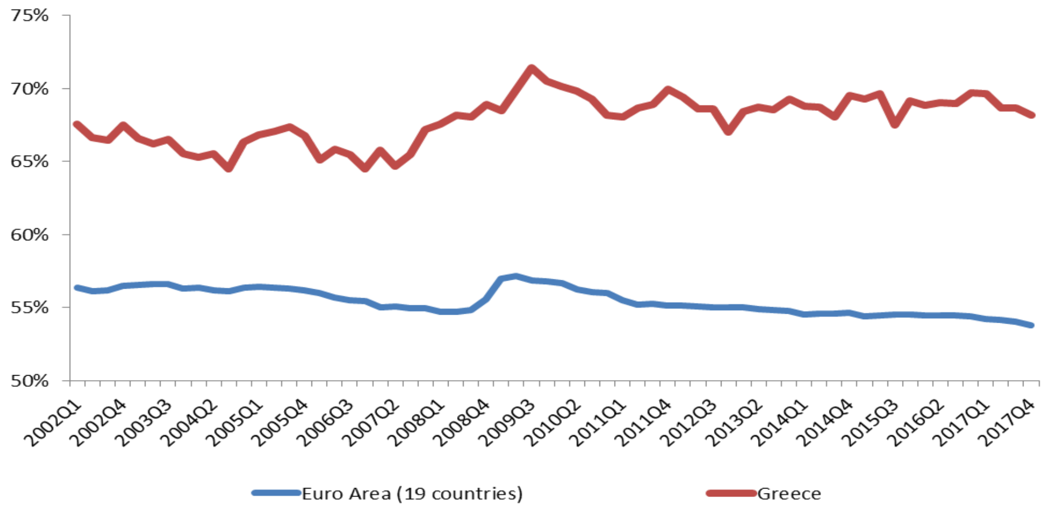
* Denotes significance at 10% level

** Denotes significance at 5% level

***Denotes significance at 1% level

Figures

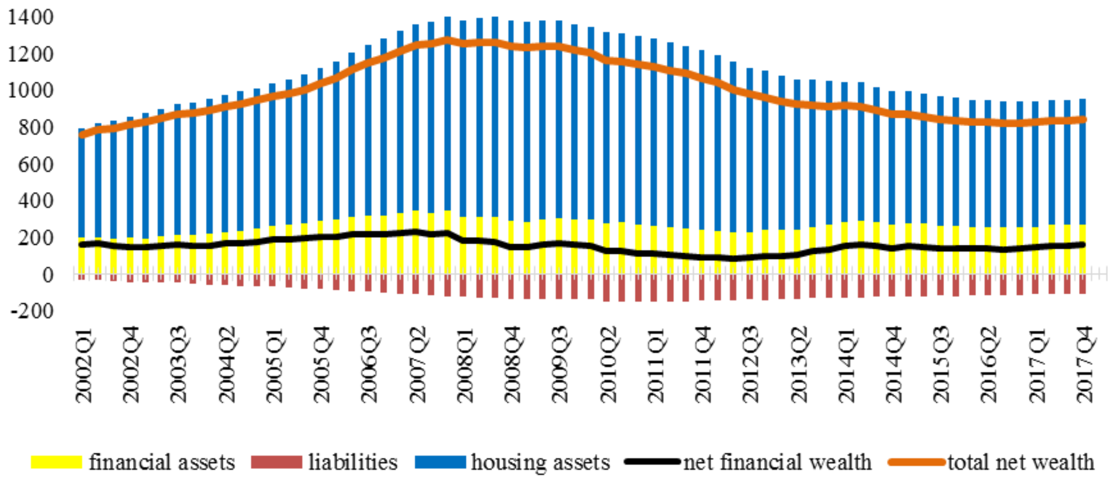
Figure 1: Consumption share to GDP - Euro Area and Greece



Sources: Eurostat, Hellenic Statistical Authority (HSA) and authors' calculations.

Figure 2: Household net wealth

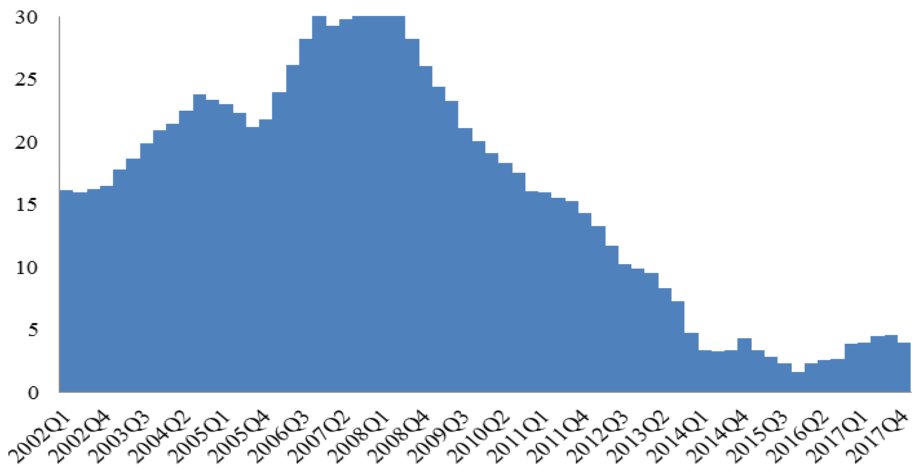
(outstanding amounts at billion euros)



Sources: Bank of Greece, European Central Bank and authors' calculations.

Figure 3: Household housing investment

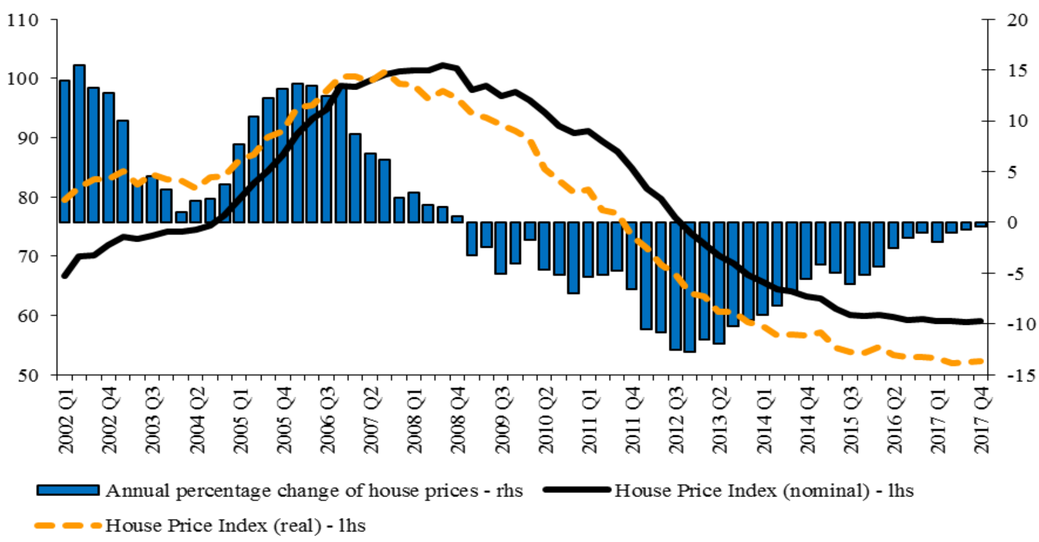
(in billion euros, four quarter moving sum)



Sources: Hellenic Statistical Authority (HSA) and authors' calculations.

Figure 4: House price index

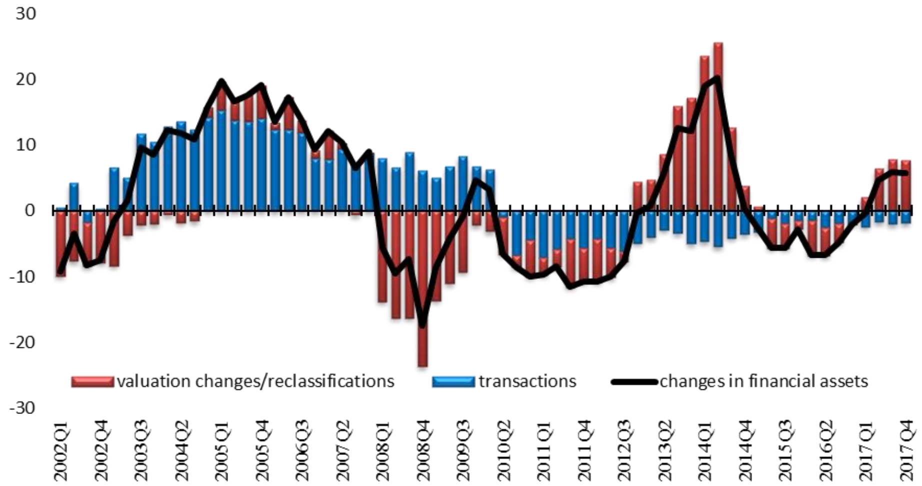
(2007=100 and annual percentage change)



Source: Bank of Greece.

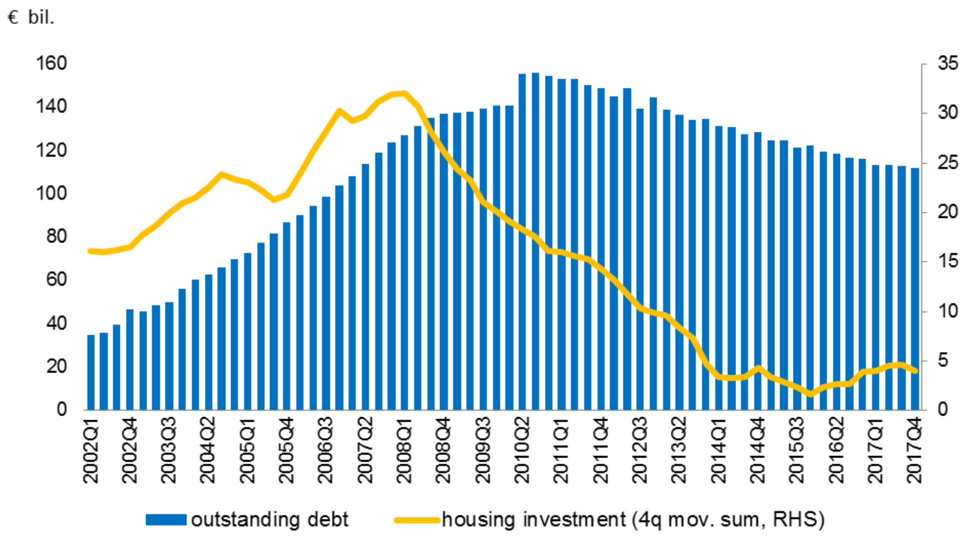
Figure 5: Changes in household financial assets

(annual percentage changes and percentage point contributions)



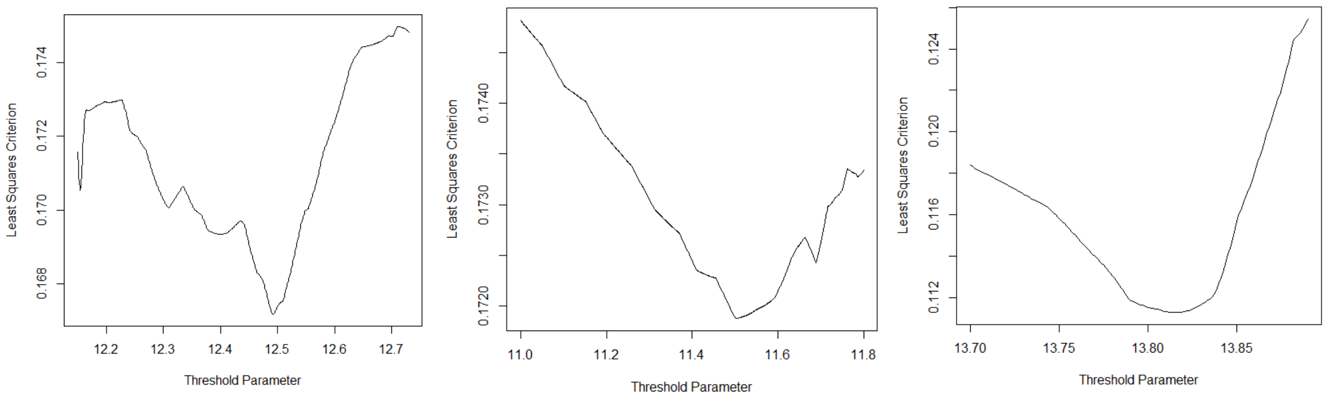
Sources: Bank of Greece and authors' calculations.

Figure 6: Household debt and housing investment (in billion euros)



Sources: Hellenic Statistical Authority (HSA), Bank of Greece and authors' calculations.

Figure 7: Least square criterion and threshold parameters



(a) Financial assets (b) Financial liabilities (c) Housing wealth

Tables

Table 1: Long-run (cointegrating) relationship using FMOLS
Dependent variable: $\ln cr$

Variable	estimate	Std Error	t-statistic
$\ln rdi$	0.589*** (0.000)	0.052	11.36
$\ln asset$	0.050** (0.051)	0.026	1.95
$\ln liab$	0.086*** (0.000)	0.012	6.92
$\ln hw$	0.088** (0.081)	0.050	1.75
intercept	1.457*** (0.000)	0.350	4.17
R^2 (Adjusted)	0.9322		
S.E of Regression	0.0438		
Sample period	1999Q1-2017Q4		

* Denotes significance at 10% level

** Denotes significance at 5% level

***Denotes significance at 1% level

Table 2: Marginal Propensity to Consume (MPC) results

Variable	estimated MPC (mpc)	estimated elasticities (ε)
$\ln rdi$	0.573	0.589
$\ln asset$	0.006	0.050
$\ln liab$	0.028	0.086
$\ln hw$	0.003	0.088

Notes:The marginal propensity to consume (MPC) with respect to each category of wealth and income is calculated according to the following formula:

$$\varepsilon = \left(\frac{\Delta cr}{cr}\right) / \left(\frac{\Delta W}{W}\right) = \left(\frac{\Delta cr}{\Delta W}\right) / \left(\frac{W}{cr}\right) = mpc\left(\frac{W}{cr}\right) \quad (1)$$

where ε is the elasticity of consumption with respect to the corresponding wealth category or disposable income and mpc is the marginal propensity to consume out of the corresponding wealth category or disposable income. Solving (1) with respect to the mpc , (2) is calculated as follows:

$$mpc = \varepsilon\left(\frac{cr}{w}\right) \quad (2)$$

Table 3: Results of threshold cointegration estimations

Estimate	cTAR	cMTAR	cTAR	cMTAR	cTAR	cMTAR
Threshold variable	$\ln asset_{t-1}$ 12.269	$\Delta \ln asset_{t-1}$ 0.033	$\ln liab_{t-1}$ 10.787	$\Delta \ln liab_{t-1}$ 0.051	$\ln hw_{t-1}$ 13.428	$\Delta \ln hw_{t-1}$ 0.024
ρ_1	-0.891*** (0.000)	-0.527** (0.042)	-0.790*** (0.000)	-1.825*** (0.000)	-0.796*** (0.000)	-1.365*** (0.000)
ρ_2	-1.434*** (0.000)	-1.113*** (0.000)	-1.581*** (0.000)	-0.865*** (0.000)	-1.602*** (0.000)	-0.789** (0.014)
Diagnostics						
AIC	-309.180	-309.900	-315.249	-314.245	-315.290	-311.607
BIC	-304.545	-305.265	-310.614	-309.610	-310.655	-306.972
Hypotheses						
$\Phi(H_0 : \rho_1 = \rho_2 = 0)$ no cointegration	39.59***	40.32***	46.00***	44.91***	46.05***	42.09***
$F(H_0 : \rho_1 = \rho_2)$ symmetry	3.50*	4.24**	9.95***	8.85***	9.99***	6.02**

* Denotes significance at 10% level

** Denotes significance at 5% level

***Denotes significance at 1% level

Table 4: The distribution of Φ (non-standard F-statistic)

	0 lags			1 lag			2 lags			3 lags		
Threshold variable	**0.10**	**0.05**	**0.01**	**0.10**	**0.05**	**0.01**	**0.10**	**0.05**	**0.01**	**0.10**	**0.05**	**0.01**
$\ln asset_{t-1}$	11.554	13.964	20.444	11.358	13.684	19.949	10.326	12.753	18.577	9.711	12.014	17.336
$\Delta \ln asset_{t-1}$	10.082	11.864	15.266	9.679	11.233	14.755	8.642	10.133	13.575	8.176	9.376	12.791
$\ln liab_{t-1}$	13.641	16.755	23.858	12.259	15.207	21.538	10.375	12.613	18.259	9.827	12.363	17.827
$\Delta \ln liab_{t-1}$	10.037	11.730	15.508	9.742	11.210	14.744	8.606	10.031	13.270	8.125	9.385	12.544
$\ln hw_{t-1}$	11.080	13.371	19.278	10.979	13.389	19.799	10.026	12.210	18.120	9.513	11.803	17.139
$\Delta \ln hw_{t-1}$	10.106	11.735	15.687	9.684	11.204	14.761	8.700	10.166	13.417	8.105	9.462	12.467

Table 5: Results of the asymmetric error-correction model with threshold cointegration

Threshold variable	$\Delta Lnasset_{t-1}$ 0.033		$Lnliab_{t-1}$ 10.787		$Lnhw_{t-1}$ 13.428	
	estimate	t-ratio	estimate	t-ratio	estimate	t-ratio
δ^{+}	0.174 (0.494)	0.68	-0.585*** (0.004)	-2.91	-0.336* (0.051)	-1.95
δ^{-}	-0.754*** (0.000)	-4.14	-0.871** (0.015)	-2.43	-0.855** (0.014)	-2.45
α_1	-0.111 (0.513)	-0.65	-0.063 (0.739)	-0.33	-0.241 (0.156)	-1.42
α_2	0.552 (0.702)	0.38	0.025 (0.879)	0.15	-0.120 (0.435)	-0.78
α_3	-0.075 (0.524)	-0.64	-0.064 (0.626)	-0.49	-0.152 (0.228)	-1.21
α_4	0.378*** (0.000)	3.69	0.376*** (0.000)	3.51	0.332*** (0.002)	3.15
β_1	-0.106 (0.322)	-0.99	-0.185 (0.118)	-1.56	-0.072 (0.498)	-0.68
β_2	-0.153* (0.092)	-1.68	-0.152 (0.136)	-1.49	-0.065 (0.498)	-0.68
β_3	-0.035 (0.647)	-0.46	-0.069 (0.427)	-0.79	-0.024 (0.780)	-0.28
β_4	0.135** (0.033)	2.13	0.085 (0.222)	1.22	0.106 (0.129)	1.52
γ_1	0.012 (0.790)	0.27	-0.001 (0.981)	-0.02	0.026 (0.627)	0.49
γ_2	-0.088* (0.058)	-1.90	-0.059 (0.252)	-1.15	-0.045 (0.391)	-0.86
γ_3	0.048 (0.295)	1.05	0.044 (0.405)	0.83	0.065 (0.213)	1.25
γ_4	0.024 (0.569)	0.57	-0.003 (0.952)	-0.06	-0.013 (0.805)	-0.25
δ_1	-0.147** (0.014)	-2.45	-0.129* (0.062)	-1.87	-0.0125 (0.072)	-1.80
δ_2	-0.154** (0.015)	-2.42	-0.168** (0.022)	-2.29	-0.140 (0.051)	-1.95
δ_3	-0.332*** (0.000)	-4.84	-0.280*** (0.000)	-3.70	-0.283 (0.000)	-3.60
δ_4	0.139*** (0.041)	2.04	0.128 (0.098)	1.65	0.156 (0.042)	2.03
ζ_1	12.805*** (0.000)	3.56	9.713** (0.014)	2.47	9.900 (0.014)	2.46
ζ_2	-26.895*** (0.005)	-2.80	-19.421* (0.066)	-1.84	-20.111 (0.062)	-1.87
ζ_3	19.776** (0.038)	2.08	13.992 (0.184)	1.33	14.725 (0.170)	1.37
ζ_4	-4.281	- 1.22	-2.983	-0.76	-3.189	-0.80

Threshold variable	$\Delta Lnasset_{t-1}$ 0.033		$Lnliab_{t-1}$ 10.787		$Lnhw_{t-1}$ 13.428	
	estimate	t-ratio	estimate	t-ratio	estimate	t-ratio
	(0.222)		(0.445)		(0.423)	
Intercept	0.006* (0.080)	1.75	0.005 0.197	1.29	0.005 (0.141)	1.47
Diagnostics						
AIC	-40.756		-40.614		-40.529	
SBIC	-37.571		-37.427		-37.342	
HQIC	-39.490		-39.346		-39.262	
Log Likelihood	1043.175		1038.058		1035.056	

* Denotes significance at 10% level

** Denotes significance at 5% level

***Denotes significance at 1% level

Table 6: Coefficient estimates and bootstrap 90% confidence intervals

Threshold variable	$Lnasset_t$ 12.492		$Lnliab_t$ 11.501		$Lnhw_t$ 13.810	
	estimate	interval	estimate	interval	estimate	interval
β_1	-0.053 (0.069)	[-0.45, 0.34]	0.023 (0.026)	[-0.02, 0.06]	0.440 (0.061)	[0.32, 0.56]
β_2	0.180 (0.122)	[-0.41, 0.77]	-0.058 (0.059)	[-0.22, 0.10]	1.190 (0.373)	[-0.23, 2.62]
$\ln cr_{t-1}$	0.904 (0.043)	[0.83, 0.98]	0.891 (0.065)	[0.78, 0.99]	0.180 (0.038)	[0.03, 0.32]
intercept	0.984 (0.453)	[0.24, 1.73]	1.152 (0.681)	[0.05, 2.24]	8.600 (0.876)	[7.06, 10.14]
γ	12.492 (0.091)	[12.15, 12.73]	11.510 (0.299)	[10.00, 11.80]	13.810 (0.029)	[13.72, 13.86]

BANK OF GREECE WORKING PAPERS

256. Eleftheriadis, P., “Solidarity in the Eurozone”, January 2019.
257. Crivellaro, E. and A. Karadimitropoulou “The Role of Financial Constraints on Labour Share Developments: Macro- and Micro-Level Evidence”, February 2019.
258. Sartzetakis, S. E., “Green Bonds as an Instrument to Finance Low Carbon Transition”, March 2019.
259. Milionis, A.E, “A Simple Return Generating Model in Discrete Time; Implications for Market Efficiency Testing”, April 2019.
260. Anastasiou, D., Z. Bragoudakis and I. Malandrakis, “Non-performing loans, governance indicators and systemic liquidity risk: evidence from Greece”, May 2019.
261. Andriopoulou, E, A. Fasianos, A. Petralias, “Estimation of the Adequate Living Expenses Threshold During the Greek Crisis”, May 2019.
262. Louri, H. and P., Migiakis, “Financing economic growth in Greece: lessons from the crisis”, June 2019.