BANCA D'ITALIA

EUROSISTEMA

Temi di Discussione

(Working Papers)

Looking behind the financial cycle: the neglected role of demographics

by Alessandro Ferrari

December 2017

Number 1149

BANCA D'ITALIA
EUROSISTEMA

Temi di discussione

(Working papers)

Looking behind the financial cycle: the neglected role of demographics

by Alessandro Ferrari

Number 1149 - December 2017

The purpose of the Temi di discussione *series is to promote the circulation of working papers prepared within the Bank of Italy or presented in Bank seminars by outside economists with the aim of stimulating comments and suggestions.*

The views expressed in the articles are those of the authors and do not involve the responsibility of the Bank.

ISSN 1594-7939 (print)
ISSN 2281-3950 (online)

Printed by the Printing and Publishing Division of the Bank of Italy

LOOKING BEHIND THE FINANCIAL CYCLE: THE NEGLECTED ROLE OF DEMOGRAPHICS

by Alessandro Ferrari*

Abstract

Data demonstrate a correlation between demographic variables and financial cycles: an increase in the working-age population is associated with an expansion of the financial cycle, that is, credit growth and increased housing prices. To account for this stylized fact, this paper uses an OLG model with data on housing prices, life-cycle of income, and consumption. A transitory baby boom, which increases the working-age population, leads to higher housing prices and household borrowing.

JEL Classification: D53, E21, E32, J11.
Keywords: financial cycle, demographic trends, overlapping generations, housing.

Contents

---

* Bank of Italy, Economic Outlook and Monetary Policy Directorate.

1 Introduction

In this paper I explore the role of demographic trends as potential drivers of the financial cycle. Leaving aside the declining trend in the fertility rate as a potential explanation (e.g. Eggertson and Mehrotra (2014), Carvalho et al. (2016)) for the fall in interest rates and asset prices, as suggested by the secular stagnation hypothesis, I focus on cyclical developments in fertility rates and show that a crucial element that triggers changes in the financial cycle is the relative size of the cohorts, determined by above or below trend population growth.

Firstly, I explore the demographic process in the last century in the US and I show that the detrended fertility rate features boom and bust episodes that, looking at the absolute number of births, have generated larger or smaller cohorts than those that would have been generated by an average population growth process. Then, I show that there is a positive correlation between the age composition of the population (the inverse dependency ratio[1]) and financial variables (such as the credit/GDP gap and house prices), with the former leading the latter. Finally, I build a three-period overlapping generations (OLG) model with demographic developments, exogenous fertility shocks and life-cycle patterns of consumption and income that, even if calibrated at micro-level, is able to match the correlation observed at aggregate level. In this model, ageing and mortality are deterministic factors: agents live for three periods and then death is a certainty. The size of the newborn cohort is determined by an exogenous shock; this is the only source of uncertainty in the model.

Newborn agents enter the model with no wealth; in the first period they earn an income, consume non-durable goods, and borrow to purchase housing. In the following period, when they are middle-aged, they earn a higher income, adjust their housing stock, pay back their debt, save for retirement and consume non-durable goods. In the last period, they become old, earn no income, get/inherit the housing of their parents (who have died) and use their accumulated wealth to finance consumption and housing. The steady state life cycle profiles of debt, consumption and housing are calibrated according to microdata evidence. Housing is in fixed supply.

The main conclusions are the following: a transitory positive demographic shock (i.e. a bigger cohort entering the economy) increases the share of workers in the economy, thus increasing consumption and per capita output. Since housing is assumed to be a complementary good and it is in fixed supply, increase in output leads to a higher demand that must be cleared through a price increase. As a result, the cohorts that were alive in the previous period and that have already bought houses become relatively richer. An agent from the

[1]The inverse dependency ratio is the ratio between the number of people of working age and those out of the labour force, either because they are too young (below 15) or too old (above 64). It can be read as the number of workers that sustain an individual that is not in the labour force. The indicator takes into account the demographic structure but not the labour market status, and therefore is not affected by business cycle fluctuations.

newborn cohort, on the other hand, is relatively poorer and therefore borrows relatively less than an individual born in a steady state. The overall amount of credit increases when the demographic shock hits the economy because of the higher number of borrowers. Any agent from the baby boom cohort is poorer than an agent born in a normal size cohort and therefore owns a smaller amount of total wealth; on the contrary, the cohort of baby-boomers is richer on aggregate than a steady state size cohort and therefore owns a bigger share of wealth.

Since the shock is assumed to be temporary, when the baby-boomers become middle-aged, the new young cohort returns to its steady state size; the economy reaches a peak in terms of output, as the middle-aged agents are more productive than young workers. House prices also reach their maximum. Given that there is a partial no-arbitrage condition between housing and bonds[2], the negative perspective on house prices depresses the interest rate on bonds thus benefiting the newborn cohort with extremely accommodative credit conditions, due to the relatively larger size of the cohort that supplies credit with respect to the one that demands it.

With reference to the current debate that opposes the secular stagnation hypothesis[3] and to the financial cycle view[4], the paper offers two insights: on the one hand financial downturns may be triggered by changes in demographic developments (as in the secular stagnation hypothesis), on the other, the current phase of low interest rates can be part of a medium-frequency cycle (like the financial cycle) that will reverse (the model predicts the current phase of low interest rates as the temporary consequence of baby boomers ageing and its reversal in the near future as in the empirical work of Favero et al. (2016)). According to the model proposed here, the recent trends in interest rates and credit are neither the symptoms of a long-lasting "secular stagnation" nor the result of changes to regulation and monetary policy but the natural consequence of the demographic structure generated by a boom-bust demographic process.

The paper is structured as follows. Section 2 presents some stylized facts on financial and demographic cycles and life-cycle patterns of consumption and households' credit and housing. Section 3 presents the model and defines the equilibrium. Section 4 discusses the calibration and the solution of the model and section 5 presents the results. Section 6 offers some concluding remarks.

[2]If the economy was populated by investors who can buy and resell houses without using them and eventually going short, a standard no-arbitrage would apply. Since housing is part of the utility function, the no-arbitrage condition includes the utility that provides the use of housing.

[3]First developed by Hansen (1939) and nowadays championed by Summers (2014, 2016), advanced economies have entered a phase of low growth, high debt and low interest rates due to structural changes (mostly related to ageing populations and lower technological innovation growth) that are likely to persist in the future.

[4]The financial cycle view stresses the effect of debt overhang on sluggish growth with a particular focus on the role of loose monetary policy and financial regulation in driving the financial cycle (Lo and Rogoff, 2015, and Juselius et al., 2016).

2 Selected stylized facts

Housing prices, private debt and demographics are correlated in many developed countries. Nishimura (2011) highlights the positive correlation[5] existing between the inverse dependency ratio and house prices in many developed economies and argues that the most recent reversal in the dependency ratio has led to the beginning of financial crises in many of them. Piazzesi and Schneider (2016) highlight that fluctuations in mortgages explain a huge fraction of private debt fluctuations. Figure 1 plots the real house prices, the inverse dependency ratio and households' debt-to-GDP ratio in the USA; an analogous pattern for the UK is plotted in figure 2. The three series are highly correlated in both countries. Indeed, the cross-correlograms (US, figure 3; UK, figure 4) show that correlations are high (statistically different from zero) at different lags.

As to the definition of financial cycle, several alternatives may be found in the literature. Drehmann, Borio and Tsatsaronis (2012) analyse many financial indicators with different techniques and find that a good proxy of the financial cycle[6] is given by the mean of the medium frequencies of house prices, real credit and the credit-to-GDP ratio. They propose a measure of the financial cycle which is the mean of the standardized band pass filter of these series with a lower limit of 32 quarters (8 years) and an upper limit of 120 quarters (30 years). An updated series for the United States, computed following their methodology, can be found in figure 5. The correlogram in figure 5 suggests that changes in the inverse dependency ratio anticipate changes in the financial cycle by 10 years. It is important to notice that these stylized facts only look at the correlation and do not focus on the direction of causality.

Why do changes in the population structure affect prices? There is age-specific heterogeneity in income and consumption at different stages of life. Figure 8 plots some stylized facts on consumption, income and wealth at different stages of life from the Survey on Household Income and Wealth (SHIW) in Italy, while Figure 9 plots the same data for US households (income and wealth are taken from the Survey of Consumer Finances while data on consumption are taken from the Consumption and Expenditures Survey). Young households are those with a higher marginal propensity to consume and with a higher amount of debt, income is at its maximum when agents become middle-aged and decreases thereafter, consumption of goods and housing follows a pattern similar to income, and older agents are the main owners of financial assets. The model will be calibrated in order to match these stylized facts.

Finally it is important to comment on housing prices. What is the main source of variations in housing prices? As highlighted by Piazzesi and Schneider (2016) the main source

[5] The work of Saita et al. (2013) and uses a panel on the USA and Japan to show that the direction of causality runs from the demographic structure (i.e. the inverse dependency ratio to housing prices.

[6] They look for a definition of financial cycle such that reversion of the cycle is associated with financial crises.

of variation in the price of housing in the US is the value of land and not the value of any structures built on it. Knoll et al. (2017) found quantitatively similar results by extending the analysis to 14 advanced economies over almost 150 years. Since the model aims to capture movements in housing prices, this empirical evidence justifies the fixed supply model (as if agents owned land).

2.1 Demographics

In the model proposed in this paper, demographic developments are assumed to be exogenous with respect to the financial cycle. While the role of the economic cycle on fertility has been extensively studied in the literature[7], and one might therefore object that demographic developments are not fully exogenous with respect to financial cycle developments. The assumption made here is required in order to study how shocks to the size of population cohorts may affect financial variables. The demographic process in the paper is modelled as a cycle, which is consistent with the detrended series of birth rates adjusted for mortality in the United States, represented in figure 6. In the last century the (detrended and adjusted for child mortality[8]) birth rate fluctuated with a sequence of booms and busts of approximately 20 years; since the 1980s the fluctuations have decreased their magnitude and their duration as a consequence of a more stable socioeconomic environment. Indeed, the two biggest shocks in the series were generated by the Great Depression and WWII: between 1926 and 1945 economic conditions and the war led to a huge fall in the birth rate (almost 13 per cent below trend): on the other hand, the mobilization of women during WWII led to a tightened female labour market and then to younger women being crowded out of the labour market at the beginning of the 1950s, thereby generating the "baby boom"[9].

The picture does not change if instead of the birth rate we look at the total number of live births in the year (adjusted for child mortality[10]) that is represented in figure 7.

[7]Starting from the seminal work of Barro and Becker (1989), the literature has largely explored the relationship between business cycles and fertility from a theoretical and an empirical perspective, e.g. Jones and Schoonbroodt (2010, 2016), Jones et al. (2010) among others.

[8]Child mortality is computed as the number of children that die by the age of 5, that is the period of childhood where the probability of survival is minimal.

[9]Doepke et al. (2015) uses a quantitative model to show that this mechanism explains almost 80 per cent of the observed increase in fertility.

[10]The series in child mortality for the United States begins in 1933; nonetheless, I have used data from Sweden (historically lower than United States) and France (historically higher) to reconstruct the first 25 years of data. Therefore the orange line uses Sweden's mortality rate up until 1933, the grey line uses French data until the same year and the yellow line uses a mean. The different hypotheses do not dramatically change the boom-bust picture.

3 The Model

3.1 OLG structure

There are three cohorts: young, middle-aged and old. Agents stay in a cohort for one period (agents enter the model when they are 25 years old and one can imagine a period as lasting 20 years). The young and the middle-aged work while the old cohort does not earn any income from labour. Each generation lives for three periods and then dies with certainty. The size of the first cohort is determined by an exogenous process; the demographic variables are:

$$\begin{aligned} N_t^1 &= \overline{N} + \varepsilon_t \\ N_t^2 &= N_{t-1}^1 \\ N_t^3 &= N_{t-1}^2 \end{aligned}$$

Given that the demographic structure is the exogenous state variable of the economy, for notational convenience we can denote it with $\mathcal{N}_t = \{N_t^1, N_t^2, N_t^3\}$ the set that contains the dimensions of the three populations.

3.2 Households' preferences

In each period households get their utility from housing and consumption. Following the standard modelling, e.g. Piazzesi and Schneider (2016), I assume they have a CRRA utility function over a CES aggregator for housing and consumption. The intraperiod utility of a cohort i is given by $u\left(c_t^i, h_{t+1}^i\right)$:

$$u\left(c_t^i, h_{t+1}^i\right) = \frac{\left[x\left(h_{t+1}, c_t\right)\right]^{1-\sigma}}{1-\sigma}$$

where:

$$x\left(h_{t+1}, c_t\right) = \left[\left(1-\omega^h\right)\left(c_t\right)^{\frac{\eta-1}{\eta}} + \omega^h\left(h_{t+1}\right)^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}$$

The parameter ω^h determines the relative share of income used to buy housing while η measures the elasticity of substitution between housing and consumption; σ measures the inverse of the IES.

3.3 First cohort

The first cohort is formed of newly born agents. They inelastically supply one unit of labour, earn an income w_t^1 and buy consumption goods c_t^1 and housing h_{t+1}^1. They can become indebted by going negative on a risk-free bond (that is sold at q_t^b and that is paid back in the subsequent period)[11]. Therefore the problem that the representative agent faces is:

$$V_t^1(\mathcal{N}_t) = \max_{c_t^1, h_{t+1}^1, d_{t+1}^1} u\left(c_t^1, h_{t+1}^1\right) + \beta_1 \mathbb{E}_t\left[V_{t+1}^2\left(d_{t+1}^1, h_{t+1}^1, \mathcal{N}_{t+1}\right)\right]$$

$$s.t.$$

$$c_t^1 + q_t^h h_{t+1}^1 + q_t^b d_{t+1}^1 \leq w_t^1 \qquad \left(\mu_t^1\right)$$

where $u\left(c_t^1, h_{t+1}^1\right)$ is the function described above.

3.4 Second cohort

When they are middle-aged, the inelastic labour supply of agents is still one unit of time and they earn an income w_t^2 which they use to buy consumer goods c_t^2 and eventually to adjust their amount of housing h_{t+1}^2. They have to pay back the debts incurred in the first period and can save money for their retirement by lending to the first cohort. Therefore the problem faced by the representative agent of the cohort is:

$$V_t^2\left(d_t^1, h_t^1, \mathcal{N}_t\right) = \max_{c_t^2, h_{t+1}^2, d_{t+1}^2} u\left(c_t^2, h_{t+1}^2\right) + \beta_2 \mathbb{E}_t\left[V_{t+1}^3\left(d_{t+1}^2, h_{t+1}^2, \mathcal{N}_{t+1}\right)\right]$$

$$s.t.$$

$$c_t^2 + q_t^h\left(h_{t+1}^2 - h_t^1\right) + q_t^b d_{t+1}^2 \leq w_t^2 + d_t^1 \qquad \left(\mu_t^2\right) \tag{1}$$

3.5 Third cohort

In the last period of their life agents do not work, inherit housing from their parents ($h_t^3 \frac{N_{t-1}^3}{N_t^3}$, where the second term takes into account that cohorts may differ in size, (which affects the amount of inheritance) and use their financial and real wealth to maximize their utility. The problem faced by the representative agent of the third cohort is:

$$V_t^3\left(d_t^2, h_t^2, \mathcal{N}_t\right) = \max_{c_t^2, h_{t+1}^2} u\left(c_t^3, h_{t+1}^3\right)$$

$$s.t.$$

$$c_t^3 + q_t^h\left(h_{t+1}^3 - h_t^2\right) \leq d_t^2 + q_t^h h_t^3 \frac{N_{t-1}^3}{N_t^3} \qquad \left(\mu_t^3\right) \tag{2}$$

3.6 Representative firm

The main results of the paper can be obtained with a simpler age-dependent endowment economy. Nonetheless, in order to capture the effects of larger or smaller than usual cohorts the representative firm has a production function with a CES aggregator for labour input

[11] Notice that the bond market in principle allows the first cohort to save, and they become indebted only if it occurs endogenously $d_{t+1}^1 < 0$.

from young and middle-aged workers. In the literature there has been much discussion on the effect of cohort size in the labour market performances of an agent, and this model allows us to capture inter-cohort complementarities and intra-cohort substitutabilities of labour input. As a result the life-cycle profiles of income of baby boomers and baby busters will be affected: being born in a larger than usual cohort will reduce the per capita wage (intra-cohort substitutability), on the contrary the other cohorts at work will benefit from higher productivity (inter-cohort complementarity). Capital is assumed to be in fixed supply so as not to increase the state-space dimensionality; the role of this assumption will be discussed in section 5.3. The CES aggregator is calibrated by looking at empirical estimates on complementarity and substitutability between young and middle-aged workers[12].

The production sector includes one representative firm that produces consumption goods taking as its input young and middle-aged labour. The production does not require capital. The problem faced by the firm is:

$$\max_{N_t^1, N_t^2, K_t^1} \qquad Y_t - w_t^1 N_t^1 - w_t^2 N_t^2$$
$$s.t.$$
$$Y_t = \left[\omega^y \left(N_t^1\right)^{\frac{\varepsilon-1}{\varepsilon}} + \omega^o \left(N_t^2\right)^{\frac{\varepsilon-1}{\varepsilon}}\right]^{\frac{\varepsilon}{\varepsilon-1}}$$

Notice that the labour of the young and of the middle-aged have different levels of productivity and are complements in production; ε captures the level of complementarity, $\omega^y + \omega^o = 1$ captures the different levels of productivity through the life cycle while ε represents the elasticity of substitution between young and old workers in production. Therefore the FOCs are:

$$\begin{aligned} w_t^1 &= \frac{Y_t}{N_t^1} \frac{\omega^y \left(N_t^1\right)^{\frac{\rho-1}{\rho}}}{\omega^y \left(N_t^1\right)^{\frac{\rho-1}{\rho}} + \omega^o \left(N_t^2\right)^{\frac{\rho-1}{\rho}}} \\ w_t^2 &= \frac{Y_t}{N_t^2} \frac{\omega^o \left(N_t^2\right)^{\frac{\rho-1}{\rho}}}{\omega^y \left(N_t^1\right)^{\frac{\rho-1}{\rho}} + \omega^o \left(N_t^2\right)^{\frac{\rho-1}{\rho}}} \end{aligned}$$

3.7 Housing market

There is a fixed housing supply (as already discussed it represents land); the exogenous amount of housing $\overline{H}$ is shared among all living individuals. The housing used by the third cohort is inherited by their children (the following cohort) at the end of the period.

In this economy housing plays a double role: agents get instant utility from owning it but

[12]For example Macunovich (1999), Murphy et al. (1984), Levine and Mitchel (1988) among others.

it is also an investment that can be sold in the next period. For this reason the return of a housing good enters into the Euler equation of cohort 1 and 2 and there is a no-arbitrage condition between the price of housing and the price of the bond. Looking at the first cohort[13] The FOCs with respect to h^1_{t+1} and d^1_{t+1} are:

$$\begin{aligned} q^h_t \mu^1_t &= \frac{\omega^h \left(h^1_{t+1}\right)^{-\frac{1}{\eta}}}{\left[\left(1-\omega^h\right)\left(c^1_t\right)^{\frac{\eta-1}{\eta}} + \omega^h \left(h^1_{t+1}\right)^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta\sigma-1}{\eta-1}}} + \beta_1 \mathbb{E}_t \left[\mu^2_{t+1} q^h_{t+1}\right] \\ q^b_t \mu^1_t &= \beta_1 \mathbb{E}_t \left[\mu^2_{t+1}\right] \end{aligned}$$

Notice that if housing does not enter the utility function, the first term on the right hand side of the first equation equals zero $\left(\frac{\omega^h \left(h^1_{t+1}\right)^{-\frac{1}{\eta}}}{\left[\left(1-\omega^h\right)\left(c^1_t\right)^{\frac{\eta-1}{\eta}} + \omega^h \left(h^1_{t+1}\right)^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta\sigma-1}{\eta-1}}} = 0\right)$ and the model predicts a standard no-arbitrage condition with $\frac{\mathbb{E}_t\left[\mu^2_{t+1}\right]}{\mu^1_t q^b_t} = \frac{\mathbb{E}_t\left[\mu^2_{t+1} q^h_{t+1}\right]}{\mu^1_t q^h_t}$. In this case, since housing delivers utility today too, agents are willing to hold it even if the expected return is lower than the bond return $\left(\frac{\omega^h \left(h^1_{t+1}\right)^{-\frac{1}{\eta}}}{\left[\left(1-\omega^h\right)\left(c^1_t\right)^{\frac{\eta-1}{\eta}} + \omega^h \left(h^1_{t+1}\right)^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta\sigma-1}{\eta-1}}} > 0 \implies \frac{\mathbb{E}_t\left[\mu^2_{t+1}\right]}{\mu^1_t q^b_t} < \frac{\mathbb{E}_t\left[\mu^2_{t+1} q^h_{t+1}\right]}{\mu^1_t q^h_t}\right)$. Nonetheless the return on housing and bonds must be (partially) correlated.

3.8 Markets

There are three markets in this economy: the housing market, the bond market and the goods market. All agents participate in the housing and goods market while only the young and middle-aged trade on the financial market[14]. Market clearing conditions are:

$$\begin{aligned} N^1_t h^1_{t+1} + N^2_t h^2_{t+1} + N^3_t h^3_{t+1} &= \overline{H} \\ N^1_t d^1_{t+1} + N^2_t d^2_{t+1} &= 0 \\ N^1_t c^1_t + N^2_t c^2_t + N^3_t c^3_t &= Y_t \end{aligned}$$

3.9 Equilibrium of the economy

Given a sequence of shocks to the demographic process $\{\varepsilon_t\}^\infty_{t=0}$, an initial asset allocation $\{d^1_0, d^2_0\}$ and an initial split of housing between cohorts $\{h^1_0, h^2_0, h^3_0\}$, a competitive equilib-

[13]The same analysis can be conducted on the second cohort, and the main difference is in the discount factor (β_2 instead of β_1).

[14]The old are free to participate in the financial market but they do not want to save since they do not display intergenerational altruism and no one is willing to lend to them since they will no longer be alive when the loan has to be repaid.

rium for this economy is given by a sequence of allocations of housing and consumption $\left\{c_t^1, c_t^2, c_t^3, h_{t+1}^1, h_{t+1}^2, h_{t+1}^3\right\}_{t=0}^{\infty}$, a sequence of prices $\left\{q_t^h, q_t^b\right\}_{t=0}^{\infty}$ and a sequence of asset allocations $\left\{d_{t+1}^1, d_{t+1}^2\right\}_{t=0}^{\infty}$ such that $\forall t$:

1. The representative agent of the first cohort takes as given q_t^b and q_t^h and chooses c_t^1, h_{t+1}^1 and d_{t+1}^1 to solve her problem and therefore they satisfy:

$$\begin{aligned}
\mu_t^1 &= \left(1-\omega^h\right)\left(c_t^1\right)^{-\frac{1}{\eta}}\left[\left(1-\omega^h\right)\left(c_t^1\right)^{\frac{\eta-1}{\eta}}+\omega^h\left(h_{t+1}^1\right)^{\frac{\eta-1}{\eta}}\right]^{\frac{1-\eta\sigma}{\eta-1}} \\
\mu_t^1 q_t^h &= \omega^h\left(h_{t+1}^1\right)^{-\frac{1}{\eta}}\left[\left(1-\omega^h\right)\left(c_t^1\right)^{\frac{\eta-1}{\eta}}+\omega^h\left(h_{t+1}^1\right)^{\frac{\eta-1}{\eta}}\right]^{\frac{1-\eta\sigma}{\eta-1}} \\
&\quad +\beta_1\mathbb{E}_t\left[\mu_{t+1}^2 q_{t+1}^h\right] \\
q_t^b\mu_t^1 &= \beta_1\mathbb{E}_t\left[\mu_{t+1}^2\right] \\
w_t^1 &= c_t^1+q_t^h h_{t+1}^1+q_t^b d_{t+1}^1
\end{aligned}$$

2. The representative agent of the second cohort takes as given the prices q_t^b and q_t^h and the amount of bonds and housing bought in the previous period (d_t^1 and h_t^1) and chooses c_t^2, h_{t+1}^2 and d_{t+1}^2 to solve her problem. The associated FOCs are:

$$\begin{aligned}
\mu_t^2 &= \left(1-\omega^h\right)\left(c_t^2\right)^{-\frac{1}{\eta}}\left[\left(1-\omega^h\right)\left(c_t^2\right)^{\frac{\eta-1}{\eta}}+\omega^h\left(h_{t+1}^2\right)^{\frac{\eta-1}{\eta}}\right]^{\frac{1-\eta\sigma}{\eta-1}} \\
\mu_t^2 q_t^h &= \omega^h\left(h_{t+1}^2\right)^{-\frac{1}{\eta}}\left[\left(1-\omega^h\right)\left(c_t^2\right)^{\frac{\eta-1}{\eta}}+\omega^h\left(h_{t+1}^2\right)^{\frac{\eta-1}{\eta}}\right]^{\frac{1-\eta\sigma}{\eta-1}} \\
&\quad +\beta_2\mathbb{E}_t\left[\mu_{t+1}^3 q_{t+1}^h\right] \\
\mu_t^2 q_t^b &= \beta_2\mathbb{E}_t\left[\mu_{t+1}^3\right] \\
w_t^2+d_t^1 &= c_t^2+q_t^h\left(h_{t+1}^2-h_t^1\right)+q_t^b d_{t+1}^2
\end{aligned}$$

3. The representative agent of the third cohort takes as given the prices q_t^b and q_t^h and the amount of bonds and housing bought in the previous period (d_t^2 and h_t^2) together with the amount of housing left as a bequest by the parents h_t^3 and chooses c_t^3 and h_{t+1}^3 to solve her problem. The associated FOCs are:

$$\begin{aligned}
\mu_t^3 &= \left(1-\omega^h\right)\left(c_t^3\right)^{-\frac{1}{\eta}}\left[\left(1-\omega^h\right)\left(c_t^3\right)^{\frac{\eta-1}{\eta}}+\omega^h\left(h_{t+1}^3\right)^{\frac{\eta-1}{\eta}}\right]^{\frac{1-\eta\sigma}{\eta-1}} \\
q_t^h\mu_t^3 &= \omega^h\left(h_{t+1}^3\right)^{-\frac{1}{\eta}}\left[\left(1-\omega^h\right)\left(c_t^3\right)^{\frac{\eta-1}{\eta}}+\omega^h\left(h_{t+1}^3\right)^{\frac{\eta-1}{\eta}}\right]^{\frac{1-\eta\sigma}{\eta-1}} \\
c_t^3+q_t^h h_{t+1}^3 &= d_t^2+q_t^h h_t^2+q_t^h h_t^3\frac{N_{t-1}^3}{N_t^3}
\end{aligned}$$

4. The representative firm takes as given wages w_t^1 and w_t^2 and demands labour from the

two cohorts in order to maximize its profits:

$$w_t^1 = \frac{Y_t}{N_t^1} \frac{\omega^y \left(N_t^1\right)^{\frac{\rho-1}{\rho}}}{\omega^y \left(N_t^1\right)^{\frac{\rho-1}{\rho}} + \omega^o \left(N_t^2\right)^{\frac{\rho-1}{\rho}}}$$
$$w_t^2 = \frac{Y_t}{N_t^2} \frac{\omega^o \left(N_t^2\right)^{\frac{\rho-1}{\rho}}}{\omega^y \left(N_t^1\right)^{\frac{\rho-1}{\rho}} + \omega^o \left(N_t^2\right)^{\frac{\rho-1}{\rho}}}$$

5. Housing market clears:

$$N_t^1 h_{t+1}^1 + N_t^2 h_{t+1}^2 + N_t^3 h_{t+1}^3 = \overline{H}$$

6. Goods market clears:

$$N_t^1 c_t^1 + N_t^2 c_t^2 + N_t^3 c_t^3 = Y_t$$

7. Financial market clears:

$$N_t^1 d_{t+1}^1 + N_t^2 d_{t+1}^2 = 0$$

4 Calibration and solution method

The model is calibrated to match the stylized facts described in section 2: agents borrow in the first period of their life; in the second period they repay their debt and they save for the next period thereby providing savings to the first generation; in the last period they consume all their wealth. Consumption of housing and goods is at its minimum when agents are young, it increases and reaches its peak in middle age and then decreases in the last period.

The value of the calibrated parameters is reported in table 1, while the resulting steady state profile of consumption, housing and financial assets is shown in figure 11[15]. In order to match the data, the middle-aged cohort earns a higher share of income ($\omega^o > \omega^y$) and agents discount at a higher rate from the first to the second period and at a lower rate from the second to the third period.

[15]It can be compared with the life cycle of consumption, housing and financial assets in the US and Italy in figure 12.

Parameter	Calibration
η	0.5
ω^h	0.5
σ	2
β_1	1.3
β_2	0.5
ω^y	0.4
ω^o	0.6
ρ	0.7
$\overline{H}$	3.5
$\overline{N}$	1

Table 1: Parameters calibration

The model is solved using a third-order perturbation around the steady state.

I then consider a scenario in which an unexpected demographic shock of 10 per cent occurs. The population pyramids across periods are plotted in figure 13: on the north-west the population pyramid is in a steady state, in which all cohorts are the same size, in period 1 the boomers generation is born, which is bigger than the other cohort and the population pyramid has a larger base (north-east); in period 2 a normal cohort is born and the pyramid has the bigger cohort at its centre (south-west); finally, in period 3 the boomers are at the top of the population pyramid that is now "reversed" (the largest cohort is at the top; south-east).

5 Results

Before discussing results of the simulation of the shock it is worthwile a brief discussion on the main channel of the model: consumption smoothing and intertemporal budget constraint.

5.1 The intertemporal budget constraint

Consider the problem of an agent born in period t. She solves an intertemporal maximization under the following intertemporal budget constraint[16]:

$$c_t^1 + \left(q_t^h - q_t^b q_{t+1}^h\right) h_{t+1}^1 + q_t^b c_{t+1}^2 + q_t^b \left(q_{t+1}^h - q_{t+1}^b q_{t+2}^h\right) h_{t+2}^2 + q_t^b q_{t+1}^b c_{t+2}^3 + q_t^b q_{t+1}^b q_{t+2}^h h_{t+3}^3 \leq w_t^1 + q_t^b w_1^2 + q_t^b q_{t+1}^b q_{t+2}^h h_{t+2}^3 \frac{N_t^2}{N_t^1}$$

Firstly, notice that the housing price is similar to a "rental rate" in the first and second period while it is the pure housing price in the third period (since they do not re-sell it). Then, consider that the intertemporal wealth that the agent wants to consume smoothly according

[16]The mathematical derivation is in the appendix.

to their intertemporal preferences is:

$$w_t^1 + q_t^b w_1^2 + q_t^b q_{t+1}^b q_{t+2}^h h_{t+2}^3 \frac{N_t^2}{N_t^1}$$

Notice then that it is increasing in q_t^b and q_{t+1}^b, i.e. the lower the interest rate in the economy the higher the wealth for an agent that enters the economy. Notice that q_t^h does not enter into the period 0 income, therefore any shock to the housing price does not affect the wealth of the first cohort, while it affects the wealth of those cohorts that already own housing (check equation (1) and equation (2)).

The model works through wealth shocks created by the demographic shocks and their effects on housing prices and interest rates. Given the intertemporal preferences of different cohorts, it triggers changes in the financial cycle.

5.2 Demographic shock simulation

Figure 14 shows the reaction of the economy to a baby boom shock of 10 per cent in period 1. In any subplot the black line represents the steady state level.

When the baby-boomer cohort is born, output in the economy grows (figure 12: third row, first column) as the labour force grows. Since consumption goods and housing are complementary goods but housing is in fixed supply, the extra demand for housing has to be cleared through a change in the relative price. Housing prices increase (more than proportionally due to the elasticity of the substitution of 0.5) (figure 12: first row, first column), thus increasing the wealth of the cohorts that are already in the economy and bought housing in the previous period (2 and 3). The positive wealth effect and the substitution effect (due to the increase in q^h) work in the same direction for the second and the third cohort, and thus they increase non-durable consumption (c^2 and c^3, figure 12: first row, third and quarter column respectively). On the contrary, the two effects work in opposite directions for housing: the substitution effect prevails and they (slightly) reduce its consumption (h^2 and h^3, figure 12: second row, second and third column respectively). An agent from the first cohort, by contrast, is unfavourably affected by being born in a larger than usual cohort for two main reasons: she will have a lower wage (due to the CES aggregator of labour inside the production function) and will inherit a lesser amount of housing from her parents (there is one extra child in every ten on average and parents have less housing due to the increase in the population). The lower level of income throughout life reduces borrowing needs in the first period (wealth effect). Furthermore, the price of a bond is lower due to the non-arbitrage condition with housing that has expectations of a high return due to the (expected) increase in output (substitution effect). Notice that at the aggregate level the first cohort is getting a higher share of housing even if its per capita level of housing is smaller than a normal-size cohort.

In the second period the demographic shock reverses and a smaller (normal-sized)cohort is born after the boomers. The amount of consumer goods in the economy is at its maximum, since the boomers are now middle-aged and therefore the price of housing peaks (figure 14: first row, first column). The newborns have a higher expected wealth with respect to a cohort born in "steady state" (i.e. after a high number of periods without demographic shocks) for two reasons: a higher wage when they enter the labour market and a higher amount of housing in the last period (when, in any case, it will not be worth as much as it is now). On top of the positive wealth effect, there is also a substitution effect: the relative abundance of credit supply and the no-arbitrage with housing that will have to decrease in the next period decreases the interest rate on bonds and promotes credit to the relatively impatient young households. Therefore, wealth and substitution effects lead to an increase of the per capita borrowing by the young cohort.

When the boom cohort retires, output falls and so do housing prices. In the fourth period the demographic structure reverts to its steady state level but other variables do not. Indeed, the state variables of this model are the demographic structure (exogenous) and the wealth distribution across cohorts (endogenous). When the baby boomers' cohort dies the demographic shock reverts but wealth shares are still affected by the previous shock and therefore it takes more time for the variables to return to their steady state level.

Figure 15 plots the housing prices (rescaled to fit the figure) with the inverse dependency ratio and the aggregate level of credit-to-output (i.e. taking into account cohort-dimension), i.e. the equivalent in the model of the series represented in figure 1 for the United States and in figure 2 for the United Kingdom. It can be seen that the model, despite its simplicity, is roughly able to replicate the dynamics observed in the data at the aggregate level.

5.3 Alternative assumptions

In this subsection I briefly discuss two of the most restrictive assumptions of the model, housing inheritance and the fixed-capital production function, and their effect on the financial cycle.

With respect to housing inheritance, the crucial element for the model is the life cycle profile of borrowing and saving and the wealth shock arising from being born in a small or a big cohort. The fact that agents own a house also in the last period of their life is certainly realistic; therefore the problem to be addressed is where the housing they owned goes when they die. The most natural assumption is that their children inherit their house even if they do not have altruistic motives (introducing a bequest motive through an easy warm glow model[17] This would have a positive minor effect on the interest rate and on the

[17]As in De Nardi (2004) and De Nardi and Yang (2014).

price of housing due to the fact that the future also has a value now for the third generation), nonetheless one can make two alternative assumptions: either the houses are inherited by grandchildren (it is less natural but it means inheritance around the age of 45 which can be a reasonable age) or the government takes the whole amount of housing (one can imagine a 100 per cent tax on bequests) and share the proceedings among all the living cohorts. With respect to the first hypothesis, the results would not change, the first cohort would still find it optimal to become indebted in order to smooth consumption and the second cohort would probably increase their supply of savings and buy more houses in order to sustain their consumption in the third period where they would have no income at all. On the other hand, in the 100 per cent inheritance tax model everything depends on the sharing of the proceedings. If it does not alter the borrower\lender status of the cohort, i.e. if the first cohort is still a financial borrower (with a positive net wealth, due to the fact it owns housing) while the second cohort remains a financial lender, the results would not change. Nonetheless, the higher the share of proceedings that goes to the first cohort the higher the softening of the welfare effect since bigger cohorts benefit, at least partially, from increased housing prices and small cohorts are penalized.

With respect to the introduction of physical capital, one may argue that it would amplify the results of the model. Firstly, consider that physical capital is a risky asset since the return depends on the labour supply available in the next period, which is determined by an exogenous process on the population. For this reason the greatest share of it would be owned at the beginning of production by the middle-aged (who made investments when they were young)[18]. Therefore, with respect to the steady state without capital, the youngest generation would increase its short position on safe debt to finance investments (and housing), while clearly the oldest generation would not invest in physical capital since it will not be alive to benefit from the return. A demographic shock in this setup would favour the middle-aged who already own capital. On the one hand the investments will increase, leading to an increase in output in the subsequent period and therefore to an amplification of the house prices cycle (it is determined by the fact that housing is complementary to non-durable goods). The increase in investment would not fully compensate the increase in labour supply since the old cohort that benefits from the increase in housing prices would not want to invest in it. Therefore the risk-free interest rate would increase more than in the model without capital, increasing the negative welfare effect on baby boomers.

[18] As has been discussed in Glover et al. (2014), in an OLG model with portfolio choice and $\sigma > 1$ where the share of risky assets in a portfolio decreases with age. The result comes from the fact that a younger generation has a longer time horizon for investment and it counts on the fact that it can recoup losses at a later date. This is consistent with microdata on wealth in different countries.

6 Conclusions

Starting from some stylized facts that show a correlation between demographic variables and financial variables, I have built an OLG model with housing and credit markets and an exogenous demographic process that is able to rationalize the stylized facts in data form.

In the model, a transitory baby boom triggers an expansion in the financial cycle: the entry of a large cohort has a positive impact on housing prices, favouring those cohorts that already own houses (middle-aged and old) and on the interest rate, given the relative scarcity of credit supply and the expected boom of house prices in the next period. The subsequent cohort, on the contrary, benefits from a larger credit supply and an expected fall in house prices that lowers the interest rate. As a result, newborns are relatively richer than a normal cohort even if their income in the first period is not very different; this increases credit demand in order to smooth consumption. For this reason, even when the cohort that becomes indebted is normal-sized, the amount of credit is still higher than that of a cohort in the steady state.

With respect to the current debate between the secular stagnation and the financial cycle hypotheses, the paper provides evidence that the two can be partially reconciled: the medium-frequency cycle on interest rates and credit can be generated by the medium-frequency fluctuations in demographics that we observed in the last century. If this is the case, in the US the financial cycle will reverse as soon as the retirement phase of the baby-boomers ends and the smaller cohorts from the end of 1960 retire, and therefore sooner than expected by those who support the secular stagnation hypothesis[19]. Nonetheless, the level of interest rates observed during the 1980s should not be taken as a reference since it was determined by the entry of the baby boomers into the labor force. Thereafter the cycle should reduce its amplitude, given the relative stability of the demographic process since the mid-1980s[20]. In future research the analysis should focus on the link between demographics and the outbreak of housing bubbles. To this extent, the model should incorporate semi-rational agents or informational frictions that may trigger the "rational exuberance" that has been used to justify the outbreak of the housing bubble (e.g. Kaplan et al. (2017)).

[19]The secular stagnation hypothesis was proposed in 1938 when the economic and demographic conditions were similar to today: fertility had fallen and the economy had collapsed after a financial crisis. Hansen in 1938 stated: *"it appears that prodigious growth of population in the nineteenth century was something unique in history. Gathering momentum with the progress of modern science and transportation, the absolute growth in western Europe mounted decade by decade until the Great World War [...] the advancing tide has come to a sudden halt and the accretions are dwindling toward zero"*, but ten years later the fertility rate started increasing and 60 years of unprecedented technological growth and development in human history followed (between 1945 and 2005).

[20]It is important to underline that there are fields of economics (as well as in demographics) that look at fertility as a boom and bust process with fluctuations, e.g. Jones and Schoonbroodt (2016). From this perspective one can see how the Great Moderation reflected the stabilization of the fertility rate.

References

[1] Robert J. Barro and Gary S. Becker. Fertility choice in a model of economic growth. *Econometrica*, 57(2):481–501, 1989.

[2] Carlos Carvalho, Andrea Ferrero, and Fernanda Nechio. Demographics and real interest rates: Inspecting the mechanism. *European Economic Review*, 88(C):208–226, 2016.

[3] Mariacristina De Nardi. Wealth inequality and intergenerational links. *The Review of Economic Studies*, 71(3):743–768, 2004.

[4] Mariacristina De Nardi and Fang Yang. Bequests and heterogeneity in retirement wealth. *European Economic Review*, 72:182 – 196, 2014.

[5] Matthias Doepke, Moshe Hazan, and Yishay D. Maoz. The Baby Boom and World War II: A Macroeconomic Analysis. *Review of Economic Studies*, 82(3):1031–1073, 2015.

[6] Gauti B. Eggertsson and Neil R. Mehrotra. A model of secular stagnation. Working Paper 20574, National Bureau of Economic Research, October 2014.

[7] Carlo A. Favero, Arie E. Gozluklu, and Haoxi Yang. Demographics and the Behavior of Interest Rates. *IMF Economic Review*, 64(4):732–776, November 2016.

[8] Andrew Glover, Jonathan Heathcote, Dirk Krueger, and Jose-Victor Rios-Rull. Intergenerational Redistribution in the Great Recession. Staff Report 498, Federal Reserve Bank of Minneapolis, May 2014.

[9] Alvin H. Hansen. Economic progress and declining population growth. *The American Economic Review*, 29(1):1–15, 1939.

[10] Larry E. Jones and Alice Schoonbroodt. Complements Versus Substitutes And Trends In Fertility Choice In Dynastic Models. *International Economic Review*, 51(3):671–699, 08 2010.

[11] Larry E. Jones and Alice Schoonbroodt. Baby Busts and Baby Booms: The Fertility Response to Shocks in Dynastic Models. *Review of Economic Dynamics*, 22:157–178, October 2016.

[12] Larry E. Jones, Alice Schoonbroodt, and Michele Tertilt. Fertility Theories: Can They Explain the Negative Fertility-Income Relationship? In *Demography and the Economy*, NBER Chapters, pages 43–100. National Bureau of Economic Research, Inc, May 2010.

[13] Mikael Juselius, Claudio Borio, Piti Disyatat, and Mathias Drehmann. Monetary policy, the financial cycle and ultra-low interest rates. BIS Working Papers 569, Bank for International Settlements, July 2016.

[14] Greg Kaplan, Kurt Mitman, and Giovanni L. Violante. The Housing Boom and Bust: Model Meets Evidence. CEPR Discussion Papers 12215, C.E.P.R. Discussion Papers, August 2017.

[15] Katharina Knoll, Moritz Schularick, and Thomas Steger. No Price Like Home: Global House Prices, 1870-2012. *American Economic Review*, 107(2):331–353, February 2017.

[16] Phillip B. Levine and Olivia S. Mitchell. The Baby Boom's Legacy: Relative Wages in the 21st Century. NBER Working Papers 2501, National Bureau of Economic Research, Inc, January 1988.

[17] Stephanie Lo and Kenneth Rogoff. Secular stagnation, debt overhang and other rationales for sluggish growth, six years on. BIS Working Papers 482, Bank for International Settlements, January 2015.

[18] Diane Macunovich. The Role of Relative Cohort Size and Relative Income in the Demographic Transition. Center for Policy Research Working Papers 9, Center for Policy Research, Maxwell School, Syracuse University, March 1999.

[19] Kevin Murphy, Mark Plant, and Finis Welch. Cohort Size and Earnings. UCLA Economics Working Papers 352, UCLA Department of Economics, November 1984.

[20] Kiyohiko G. Nishimura. This time may truly be different - balance sheet adjustment under population ageing. *Review*, 2011.

[21] Monika Piazzesi and Martin Schneider. Housing and macroeconomics. Working Paper 22354, National Bureau of Economic Research, June 2016.

[22] Yumi Saita, Chihiro Shimizu, and Tsutomu Watanabe. Aging and Real Estate Prices: Evidence from Japanese and US Regional Data. CARF F-Series CARF-F-334, Center for Advanced Research in Finance, Faculty of Economics, The University of Tokyo, December 2013.

[23] Lawrence H. Summers. U.S. Economic Prospects: Secular Stagnation, Hysteresis, and the Zero Lower Bound. *Business Economics*, 49(2):65–73, April 2014.

[24] Lawrence H. Summers. Secular Stagnation and Monetary Policy. *Review*, 98(2):93–110, 2016.

Appendix

A Derivation of the intertemporal budget constraint

Start from the budget constraint of the young cohort:

$$\begin{aligned} c_t^1 + q_t^h h_{t+1}^1 + q_t^b d_{t+1}^1 &\leq w_t^1 \\ c_t^1 + q_t^h h_{t+1}^1 &\leq w_t^1 - q_t^b d_{t+1}^1 \end{aligned}$$

Use the budget constraint of the second cohort to substitute for d_{t+1}^1:

$$c_{t+1}^2 + q_{t+1}^h \left(h_{t+2}^2 - h_{t+1}^1\right) + q_{t+1}^b d_{t+2}^2 - w_1^2 \leq d_{t+1}^1$$

And we get:

$$\begin{aligned} c_t^1 + q_t^h h_{t+1}^1 &\leq w_t^1 - q_t^b d_{t+1}^1 \\ c_t^1 + q_t^h h_{t+1}^1 &\leq \\ w_t^1 - q_t^b \left(c_{t+1}^2 + q_{t+1}^h \left(h_{t+2}^2 - h_{t+1}^1\right) + q_{t+1}^b d_{t+2}^2 - w_1^2\right) & \\ c_t^1 + q_t^h h_{t+1}^1 + q_t^b c_{t+1}^2 + q_t^b q_{t+1}^h \left(h_{t+2}^2 - h_{t+1}^1\right) &\leq w_t^1 + q_t^b w_1^2 - q_t^b q_{t+1}^b d_{t+2}^2 \\ c_t^1 + \left(q_t^h - q_t^b q_{t+1}^h\right) h_{t+1}^1 + q_t^b c_{t+1}^2 + q_t^b q_{t+1}^h h_{t+2}^2 &\leq w_t^1 + q_t^b w_1^2 - q_t^b q_{t+1}^b d_{t+2}^2 \qquad (3) \end{aligned}$$

Rearranging the old cohort budget constraint to get d_{t+2}^2 we have:

$$\begin{aligned} c_{t+2}^3 + q_{t+2}^h \left(h_{t+3}^3 - h_{t+2}^2\right) &\leq d_{t+2}^2 + q_{t+2}^h h_{t+2}^3 \frac{N_t^2}{N_t^1} \\ c_{t+2}^3 + q_{t+2}^h \left(h_{t+3}^3 - h_{t+2}^2\right) - q_{t+2}^h h_{t+2}^3 \frac{N_t^2}{N_t^1} &\leq d_{t+2}^2 \end{aligned}$$

And plugging it into (3):

$$\begin{aligned} c_t^1 + \left(q_t^h - q_t^b q_{t+1}^h\right) h_{t+1}^1 + q_t^b c_{t+1}^2 + q_t^b q_{t+1}^h h_{t+2}^2 &\leq \\ w_t^1 + q_t^b w_1^2 - q_t^b q_{t+1}^b \left[c_{t+2}^3 + q_{t+2}^h \left(h_{t+3}^3 - h_{t+2}^2\right) - q_{t+2}^h h_{t+2}^3 \frac{N_t^2}{N_t^1}\right] & \end{aligned}$$

And then:

$$\begin{aligned} c_t^1 + \left(q_t^h - q_t^b q_{t+1}^h\right) h_{t+1}^1 + q_t^b c_{t+1}^2 + q_t^b \left(q_{t+1}^h - q_{t+1}^b q_{t+2}^h\right) h_{t+2}^2 + q_t^b q_{t+1}^b c_{t+2}^3 + q_t^b q_{t+1}^b q_{t+2}^h h_{t+3}^3 &\leq \\ w_t^1 + q_t^b w_1^2 + q_t^b q_{t+1}^b q_{t+2}^h h_{t+2}^3 \frac{N_t^2}{N_t^1} & \end{aligned}$$

B Figures

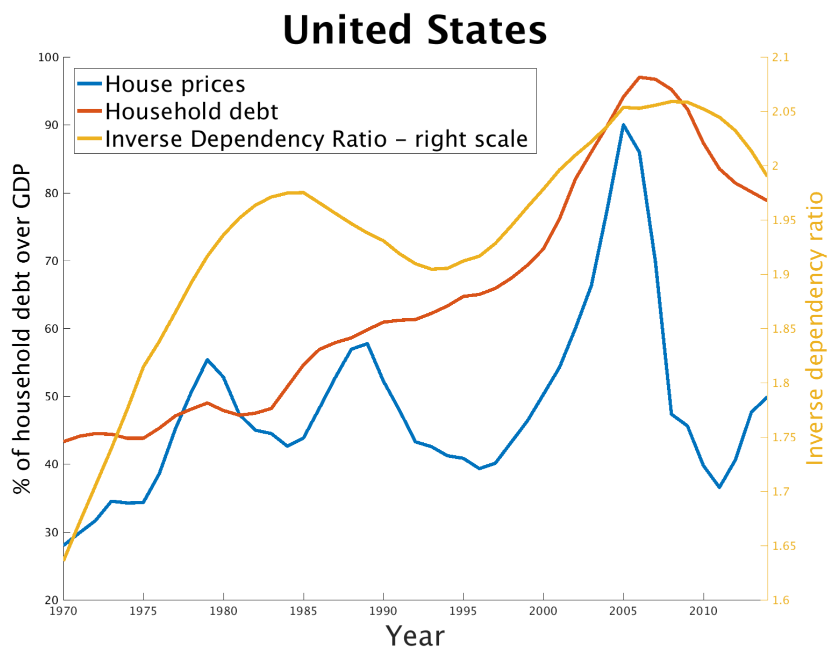

Figure 1: Historical series of house prices (BIS long series database), debt to GDP (IMF data) and inverse dependency ratio (World bank database) for United States

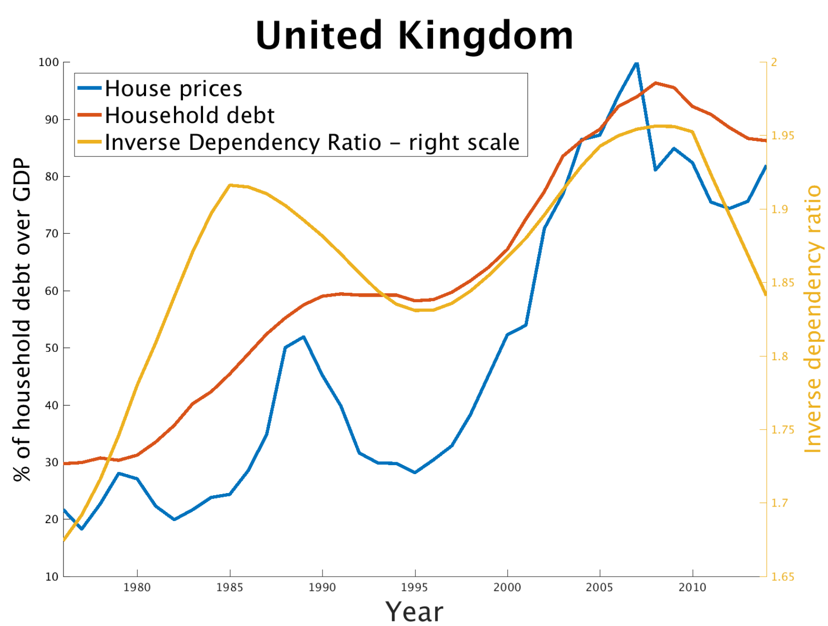

Figure 2: Historical series of house prices (BIS long series database), debt to GDP (IMF data) and inverse dependency ratio (World bank database) for United Kingdom

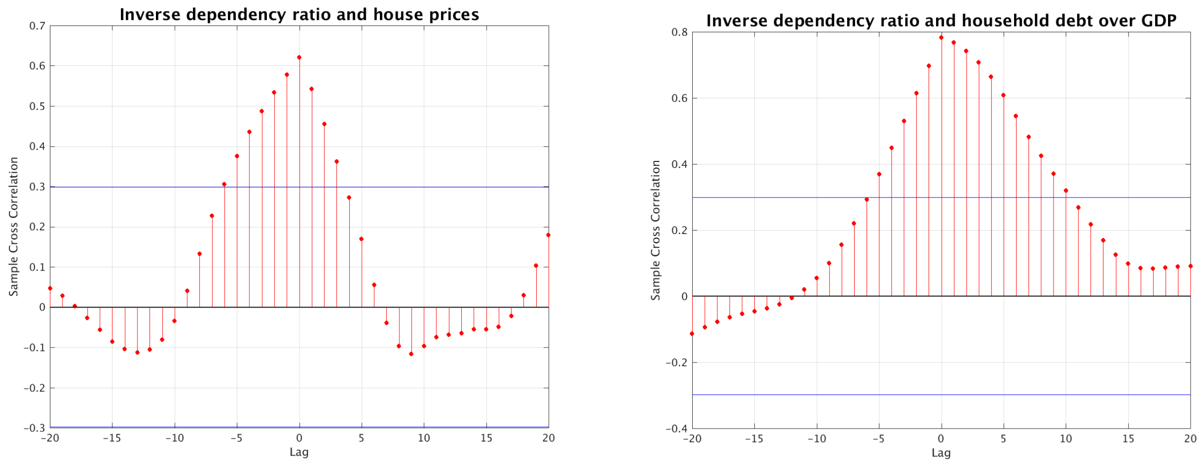

Figure 3: Cross correlograms of house prices and households debt to GDP with inverse dependency ratio in US (95% confidence bands are in blue)

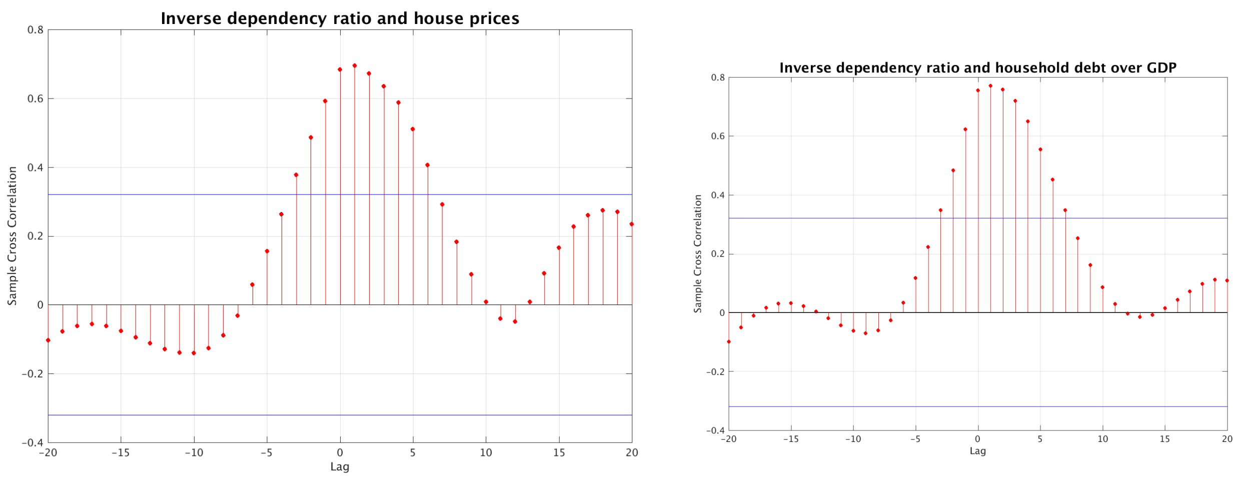

Figure 4: Cross correlograms of house prices and households debt to GDP with inverse dependency ratio in UK (95% confidence bands are in blue)

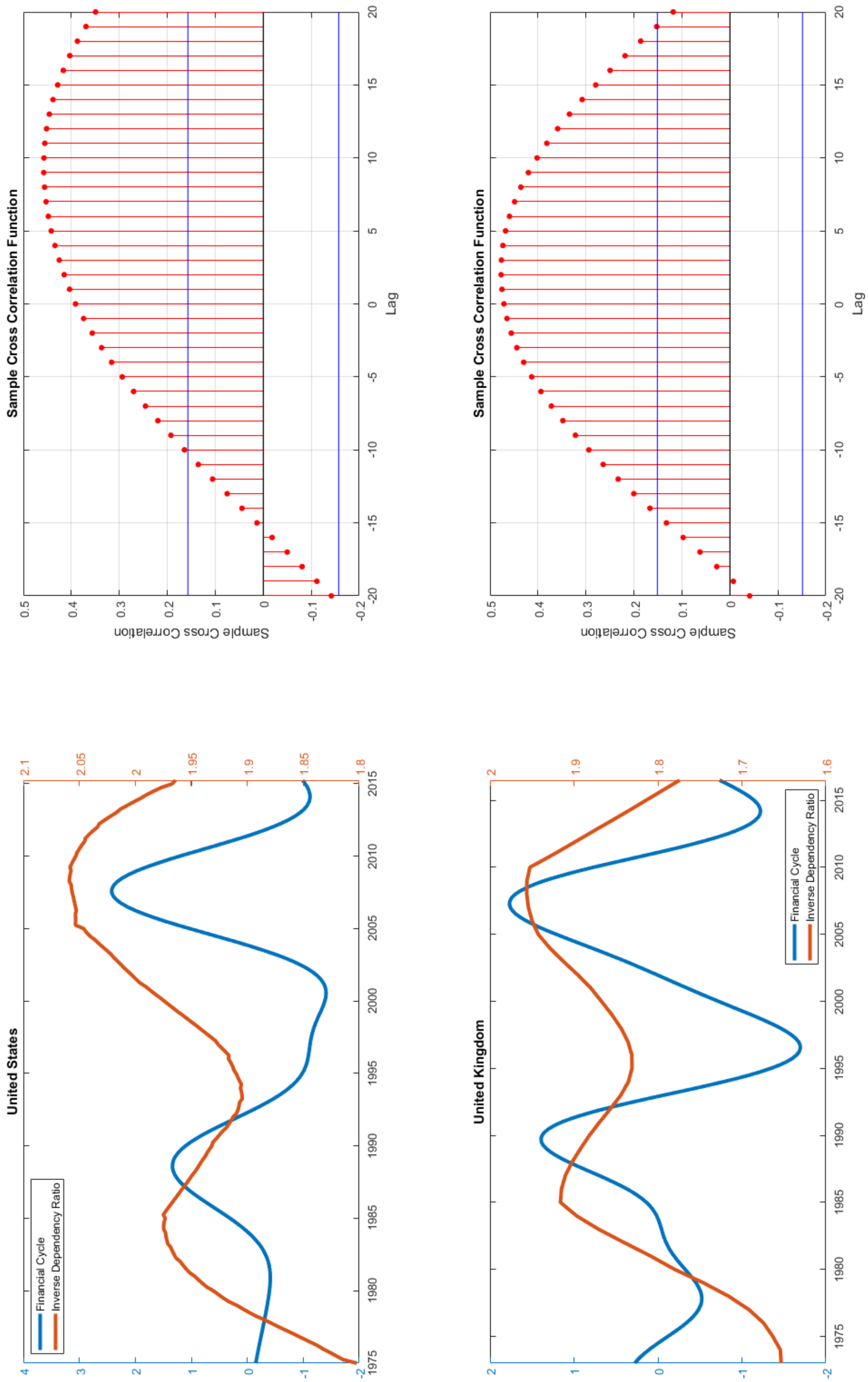

Figure 5: Financial cycle (as measured by Drehmann, Borio and Tsatsaronis (2012)) and inverse dependency ratio and correlogram for the United States and the United Kingdom

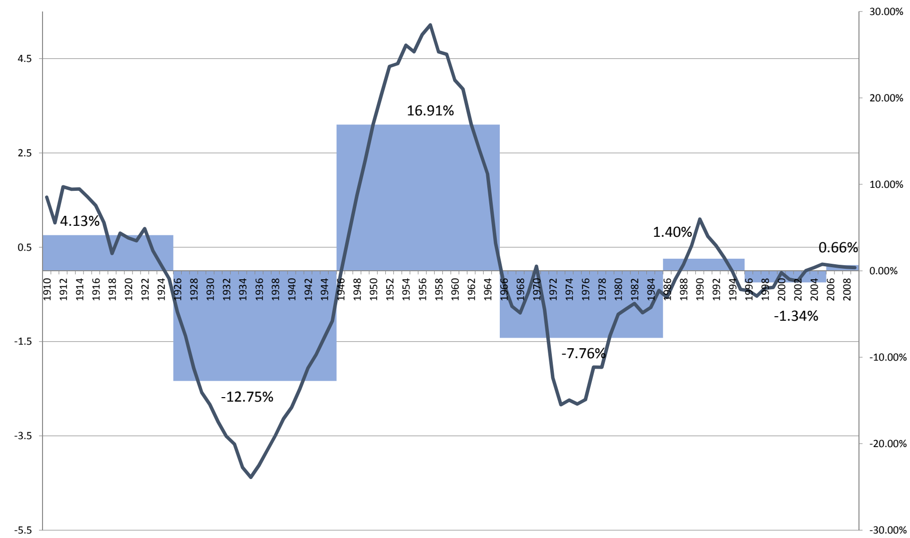

Figure 6: Detrended birth-rate, adjusted for child mortality in the United States

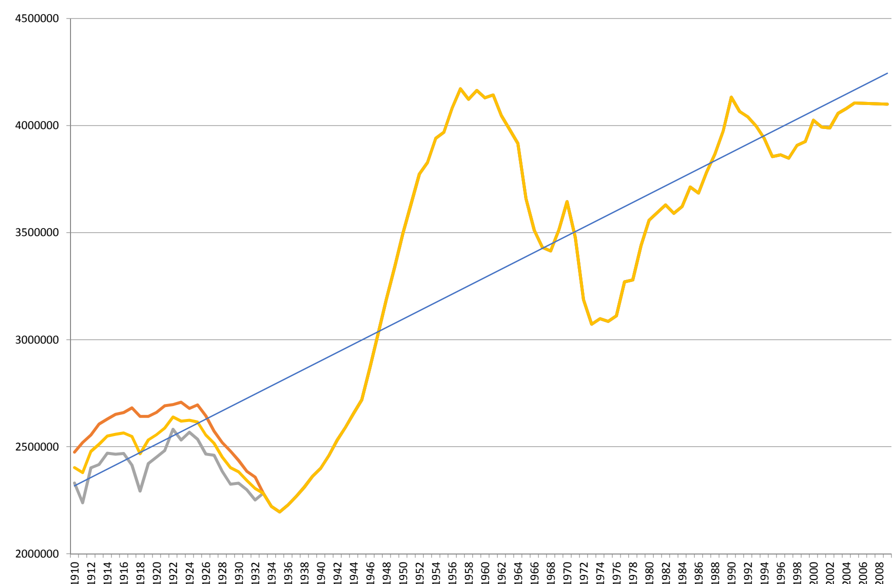

Figure 7: Live births in the US adjusted for children mortality under three alternatives hypothesis. The linear trend is traced under the central scenario.

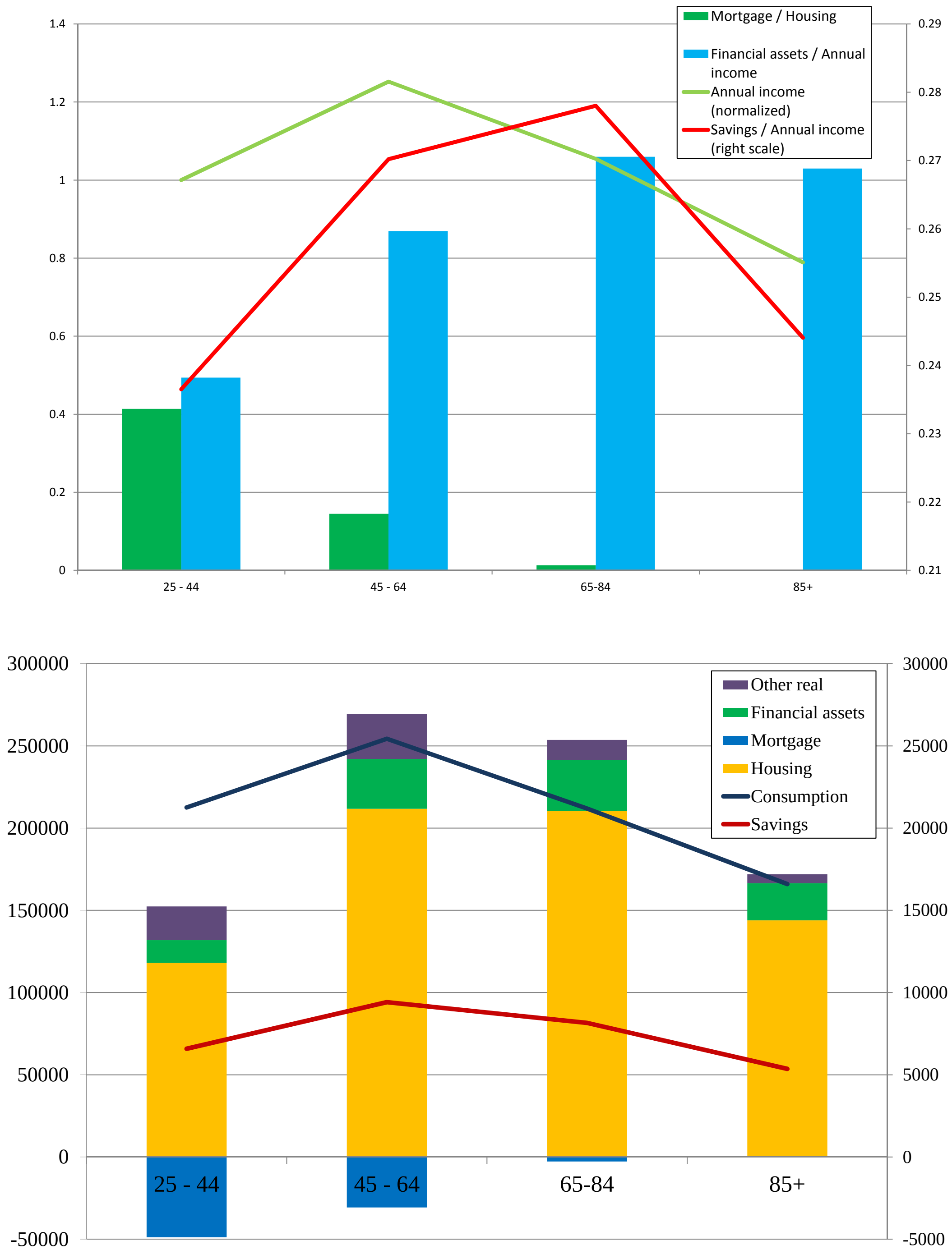

Figure 8: Life-cycle of income, savings and wealth in Italy 2014, source: SHIW

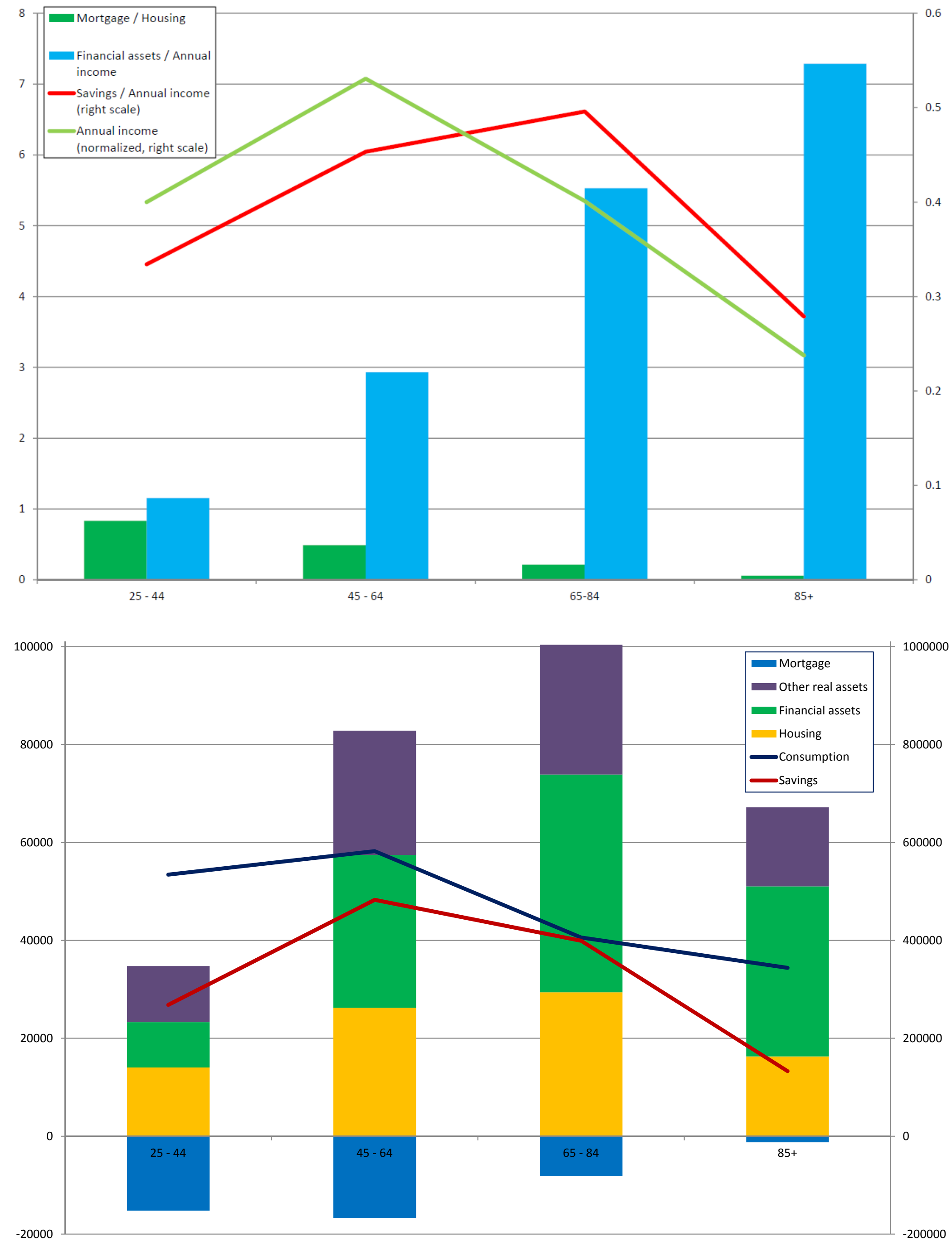

Figure 9: Life-cycle of income, savings and wealth in United States 2013, source: SCF and CE

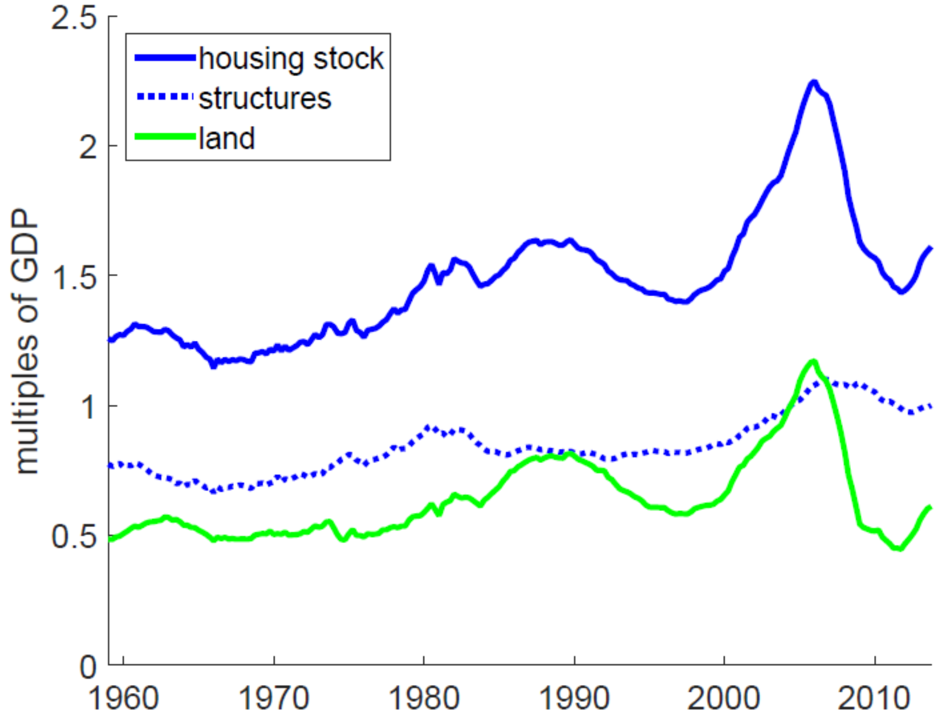

Figure 10: Historical decomposition of housing value in structures and land values (source: Piazzesi and Schneider, 2016)

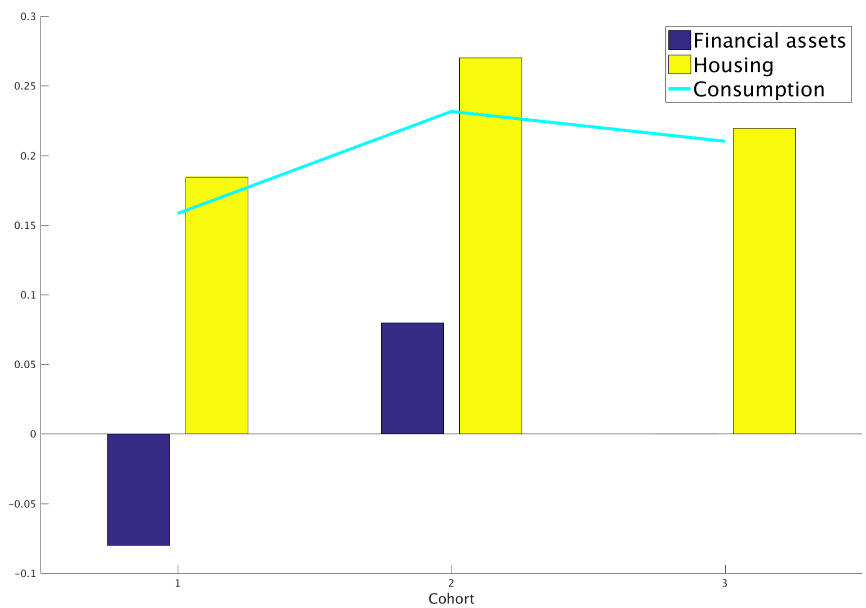

Figure 11: Steady state life-cycle of consumption, housing and financial assets in the model (end of period)

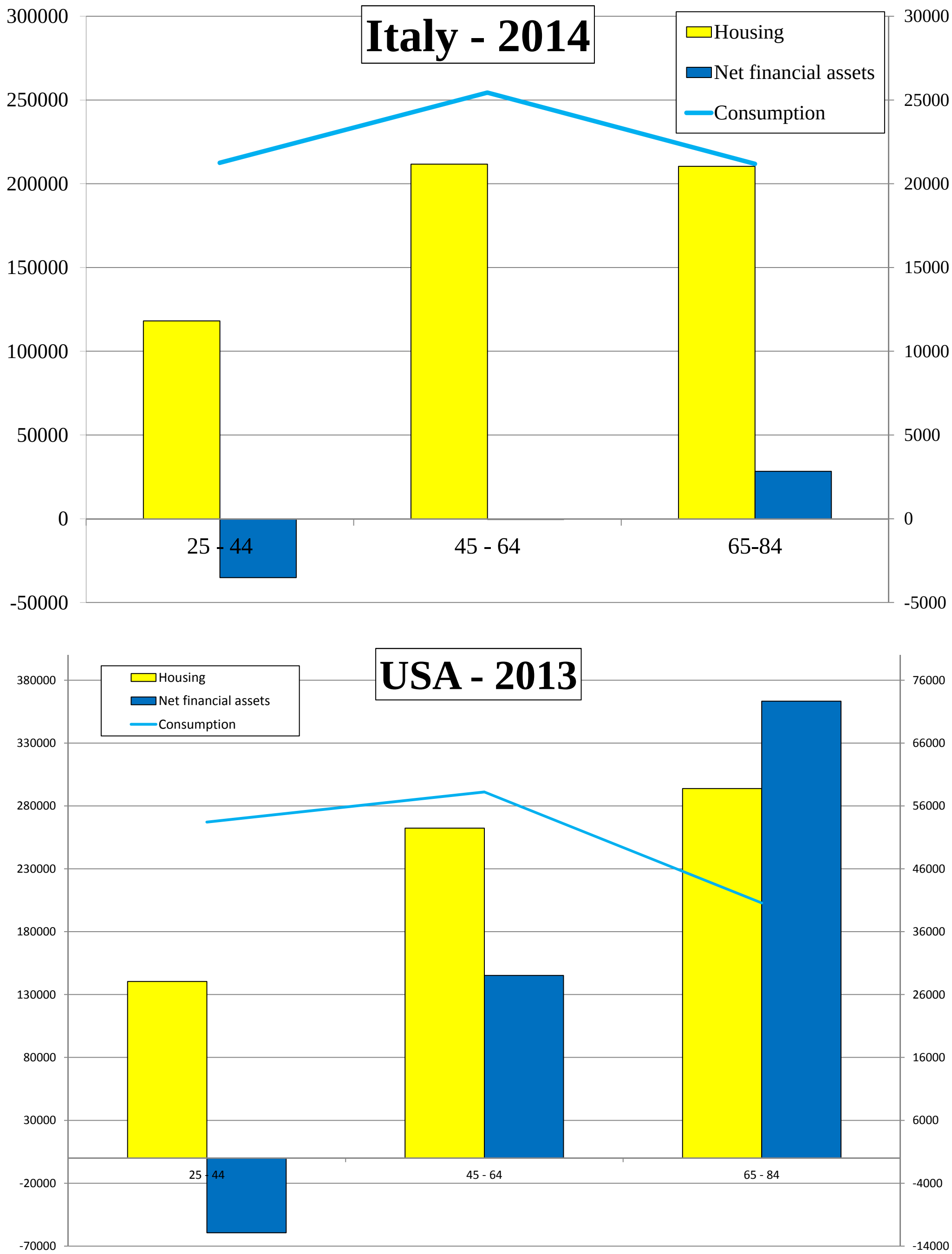

Figure 12: Life-cycle of consumption, housing and financial assets in data

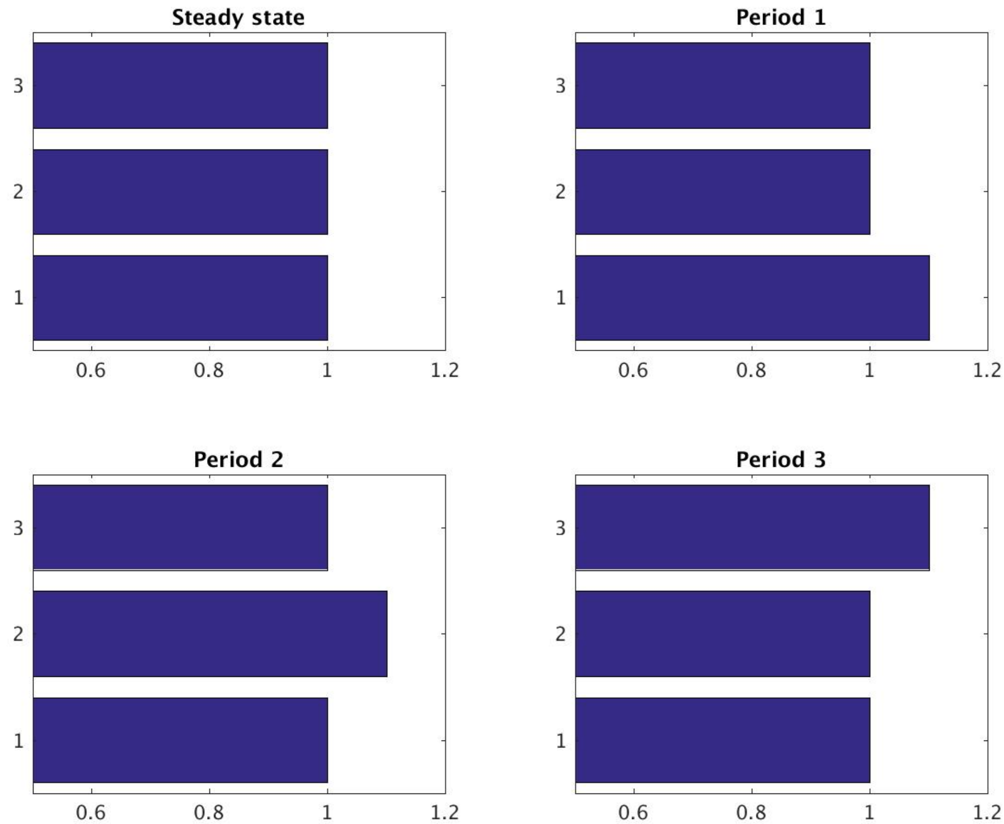

Figure 13: Population pyramid of the economy in steady state and in the following three periods.

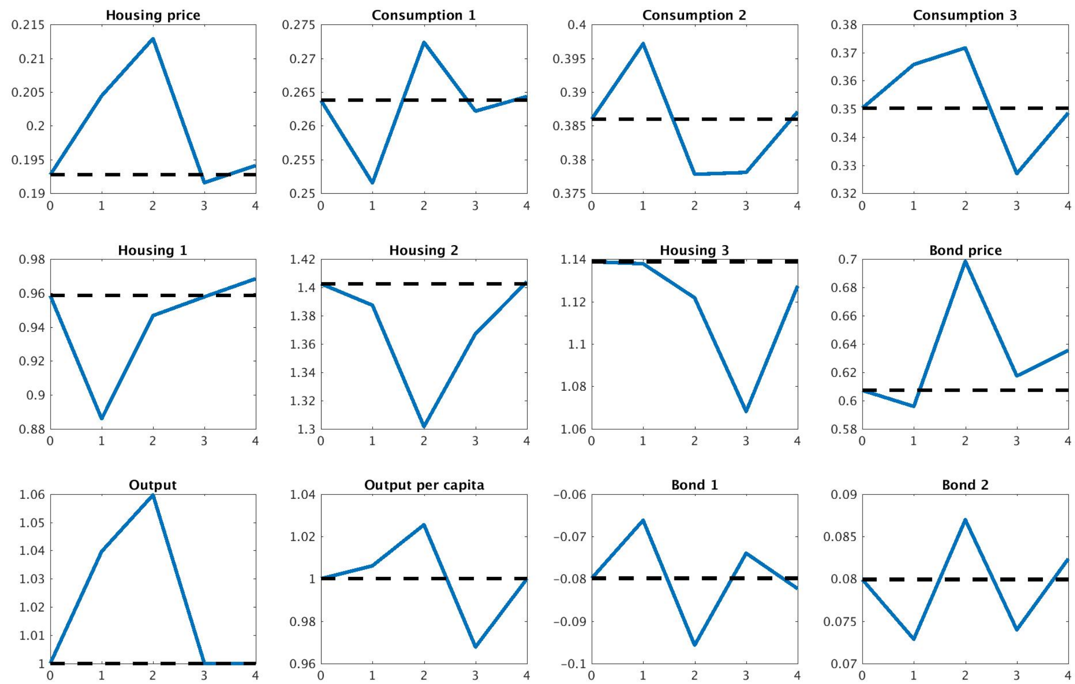

Figure 14: Patterns of the variables after a demographic shock in period 1, black lines are steady state values

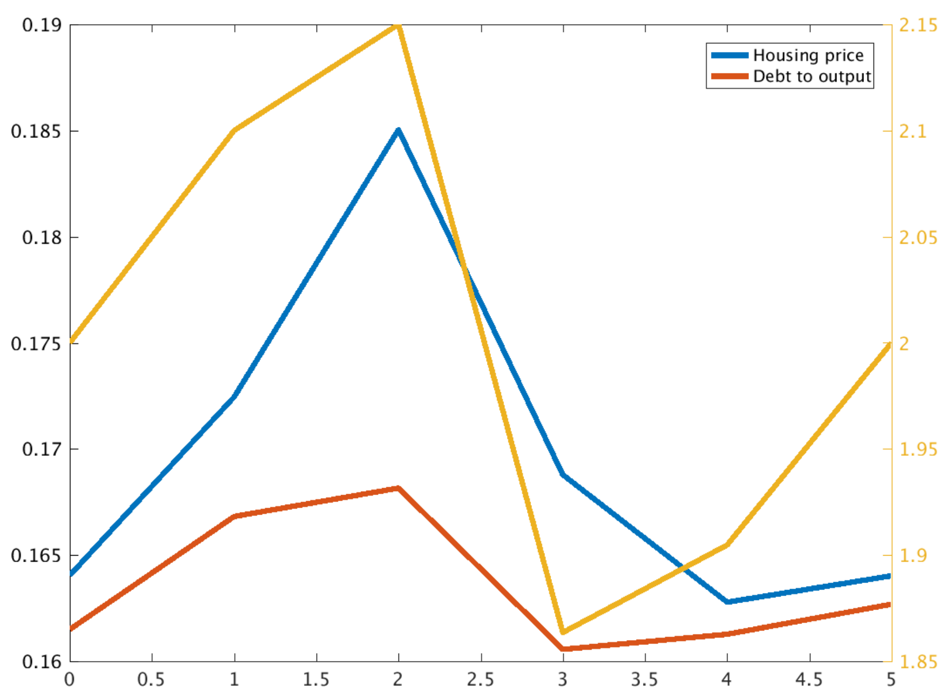

Figure 15: Housing price (blue line), debt-to-output (red line) and inverse dependency ratio (yellow line, right hand scale) with the imputed shock. On the x axis time is measured in periods of the model.

RECENTLY PUBLISHED "TEMI" (*)

N. 1129 – *The effects of central bank's verbal guidance: evidence from the ECB*, by Maddalena Galardo and Cinzia Guerrieri (July 2017).

N. 1130 – *The Bank of Italy econometric model: an update of the main equations and model elasticities*, by Guido Bulligan, Fabio Busetti, Michele Caivano, Pietro Cova, Davide Fantino, Alberto Locarno, Lisa Rodano (July 2017).

N. 1131 – *Venture capitalists at work: what are the effects on the firms they finance?*, by Raffaello Bronzini, Giampaolo Caramellino and Silvia Magri (September 2017).

N. 1132 – *Low frequency drivers of the real interest rate: a band spectrum regression approach*, by Fabio Busetti and Michele Caivano (September 2017).

N. 1133 – *The real effects of relationship lending*, by Ryan Banerjee, Leonardo Gambacorta and Enrico Sette (September 2017).

N. 1134 – *Credit demand and supply: a two-way feedback relation*, by Ugo Albertazzi and Lucia Esposito (September 2017).

N. 1135 – *Legislators' behaviour and electoral rules: evidence from an Italian reform*, by Giuseppe Albanese, Marika Cioffi and Pietro Tommasino (September 2017).

N. 1136 – *Macroeconomic effects of non-standard monetary policy measures in the euro area: the role of corporate bond purchases*, by Anna Bartocci, Lorenzo Burlon, Alessandro Notarpietro and Massimiliano Pisani (September 2017).

N. 1137 – *On secular stagnation and low interest rates: demography matters*, by Giuseppe Ferrero, Marco Gross and Stefano Neri (September 2017).

N. 1138 – *Tony Atkinson and his legacy*, by Rolf Aaberge, François Bourguignon, Andrea Brandolini, Francisco H. G. Ferreira, Janet C. Gornick, John Hills, Markus Jäntti, Stephen P. Jenkins, Eric Marlier, John Micklewright, Brian Nolan, Thomas Piketty, Walter J. Radermacher, Timothy M. Smeeding, Nicholas H. Stern, Joseph Stiglitz and Holly Sutherland (September 2017).

N. 1139 – *Credit misallocation during the European financial crisis*, by Fabiano Schivardi, Enrico Sette and Guido Tabellini (September 2017).

N. 1140 – *Natural rates across the Atlantic*, by Andrea Gerali and Stefano Neri (September 2017).

N. 1141 – *A quantitative analysis of risk premia in the corporate bond market*, by Sara Cecchetti (October 2017).

N. 1142 – *Monetary policy in times of debt*, by Mario Pietrunti and Federico M. Signoretti (October 2017).

N. 1143 – *Capital misallocation and financial development: a sector-level analysis*, by Daniela Marconi and Christian Upper (October 2017).

N. 1144 – *Leaving your mamma: why so late in Italy?*, by Enrica Di Stefano (October 2017).

N. 1145 – *A Financial Conditions Index for the CEE economies*, by Simone Auer (October 2017).

N. 1146 – *Internal capital markets in times of crisis: the benefit of group affiliation in Italy*, by Raffaele Santioni, Fabio Schiantarelli and Philip E. Strahan (October 2017).

N. 1147 – *Consistent inference in fixed-effects stochastic frontier models*, by Federico Belotti and Giuseppe Ilardi (October 2017).

N. 1148 – *Investment decisions by European firms and financing constraints*, by Andrea Mercatanti, Taneli Mäkinen and Andrea Silvestrini (October 2017).

(*) Requests for copies should be sent to:
Banca d'Italia – Servizio Studi di struttura economica e finanziaria – Divisione Biblioteca e Archivio storico – Via Nazionale, 91 – 00184 Rome – (fax 0039 06 47922059). They are available on the Internet www.bancaditalia.it.

2015

AABERGE R. and A. BRANDOLINI, *Multidimensional poverty and inequality,* in A. B. Atkinson and F. Bourguignon (eds.), Handbook of Income Distribution, Volume 2A, Amsterdam, Elsevier, **TD No. 976 (October 2014).**

ALBERTAZZI U., G. ERAMO, L. GAMBACORTA and C. SALLEO, *Asymmetric information in securitization: an empirical assessment*, Journal of Monetary Economics, v. 71, pp. 33-49, **TD No. 796 (February 2011).**

ALESSANDRI P. and B. NELSON, *Simple banking: profitability and the yield curve,* Journal of Money, Credit and Banking, v. 47, 1, pp. 143-175, **TD No. 945 (January 2014).**

ANTONIETTI R., R. BRONZINI and G. CAINELLI, *Inward greenfield FDI and innovation,* Economia e Politica Industriale, v. 42, 1, pp. 93-116, **TD No. 1006 (March 2015).**

BARONE G. and G. NARCISO, *Organized crime and business subsidies: Where does the money go?,* Journal of Urban Economics, v. 86, pp. 98-110, **TD No. 916 (June 2013).**

BRONZINI R., *The effects of extensive and intensive margins of FDI on domestic employment: microeconomic evidence from Italy*, B.E. Journal of Economic Analysis & Policy, v. 15, 4, pp. 2079-2109, **TD No. 769 (July 2010).**

BUGAMELLI M., S. FABIANI and E. SETTE, *The age of the dragon: the effect of imports from China on firm-level prices*, Journal of Money, Credit and Banking, v. 47, 6, pp. 1091-1118, **TD No. 737 (January 2010).**

BULLIGAN G., M. MARCELLINO and F. VENDITTI, *Forecasting economic activity with targeted predictors,* International Journal of Forecasting, v. 31, 1, pp. 188-206, **TD No. 847 (February 2012).**

BUSETTI F., *On detecting end-of-sample instabilities,* in S.J. Koopman, N. Shepard (eds.), Unobserved Components and Time Series Econometrics, Oxford, Oxford University Press, **TD No. 881 (September 2012).**

CESARONI T., *Procyclicality of credit rating systems: how to manage it,* Journal of Economics and Business, v. 82. pp. 62-83, **TD No. 1034 (October 2015).**

CIARLONE A., *House price cycles in emerging economies,* Studies in Economics and Finance, v. 32, 1, **TD No. 863 (May 2012).**

CUCINIELLO V. and F. M. SIGNORETTI, *Large bank, loan rate markup and monetary policy,* International Journal of Central Banking, v. 11, 3, pp. 141-177, **TD No. 987 (November 2014).**

DE BLASIO G., D. FANTINO and G. PELLEGRINI, *Evaluating the impact of innovation incentives: evidence from an unexpected shortage of funds,* Industrial and Corporate Change, v. 24, 6, pp. 1285-1314, **TD No. 792 (February 2011).**

DEPALO D., R. GIORDANO and E. PAPAPETROU, *Public-private wage differentials in euro area countries: evidence from quantile decomposition analysis,* Empirical Economics, v. 49, 3, pp. 985-1115, **TD No. 907 (April 2013).**

DI CESARE A., A. P. STORK and C. DE VRIES, *Risk measures for autocorrelated hedge fund returns,* Journal of Financial Econometrics, v. 13, 4, pp. 868-895, **TD No. 831 (October 2011).**

FANTINO D., A. MORI and D. SCALISE, *Collaboration between firms and universities in Italy: the role of a firm's proximity to top-rated departments,* Rivista Italiana degli economisti, v. 1, 2, pp. 219-251, **TD No. 884 (October 2012).**

FRATZSCHER M., D. RIMEC, L. SARNOB and G. ZINNA, *The scapegoat theory of exchange rates: the first tests,* Journal of Monetary Economics, v. 70, 1, pp. 1-21, **TD No. 991 (November 2014).**

NOTARPIETRO A. and S. SIVIERO, *Optimal monetary policy rules and house prices: the role of financial frictions,* Journal of Money, Credit and Banking, v. 47, S1, pp. 383-410, **TD No. 993 (November 2014).**

RIGGI M. and F. VENDITTI, *The time varying effect of oil price shocks on euro-area exports,* Journal of Economic Dynamics and Control, v. 59, pp. 75-94, **TD No. 1035 (October 2015).**

TANELI M. and B. OHL, *Information acquisition and learning from prices over the business cycle,* Journal of Economic Theory, 158 B, pp. 585–633, **TD No. 946 (January 2014).**

2016

ALBANESE G., G. DE BLASIO and P. SESTITO, *My parents taught me. evidence on the family transmission of values,* Journal of Population Economics, v. 29, 2, pp. 571-592, **TD No. 955 (March 2014).**

ANDINI M. and G. DE BLASIO, *Local development that money cannot buy: Italy's Contratti di Programma,* Journal of Economic Geography, v. 16, 2, pp. 365-393, **TD No. 915 (June 2013).**

BARONE G. and S. MOCETTI, *Inequality and trust: new evidence from panel data,* Economic Inquiry, v. 54, pp. 794-809, **TD No. 973 (October 2014).**

BELTRATTI A., B. BORTOLOTTI and M. CACCAVAIO, *Stock market efficiency in China: evidence from the split-share reform,* Quarterly Review of Economics and Finance, v. 60, pp. 125-137, **TD No. 969 (October 2014).**

BOLATTO S. and M. SBRACIA, *Deconstructing the gains from trade: selection of industries vs reallocation of workers,* Review of International Economics, v. 24, 2, pp. 344-363, **TD No. 1037 (November 2015).**

BOLTON P., X. FREIXAS, L. GAMBACORTA and P. E. MISTRULLI, *Relationship and transaction lending in a crisis*, Review of Financial Studies, v. 29, 10, pp. 2643-2676, **TD No. 917 (July 2013).**

BONACCORSI DI PATTI E. and E. SETTE, *Did the securitization market freeze affect bank lending during the financial crisis? Evidence from a credit register,* Journal of Financial Intermediation , v. 25, 1, pp. 54-76, **TD No. 848 (February 2012).**

BORIN A. and M. MANCINI, *Foreign direct investment and firm performance: an empirical analysis of Italian firms,* Review of World Economics, v. 152, 4, pp. 705-732, **TD No. 1011 (June 2015).**

BRAGOLI D., M. RIGON and F. ZANETTI, *Optimal inflation weights in the euro area,* International Journal of Central Banking, v. 12, 2, pp. 357-383, **TD No. 1045 (January 2016).**

BRANDOLINI A. and E. VIVIANO, *Behind and beyond the (headcount) employment rate,* Journal of the Royal Statistical Society: Series A, v. 179, 3, pp. 657-681, **TD No. 965 (July 2015).**

BRIPI F., *The role of regulation on entry: evidence from the Italian provinces,* World Bank Economic Review, v. 30, 2, pp. 383-411, **TD No. 932 (September 2013).**

BRONZINI R. and P. PISELLI, *The impact of R&D subsidies on firm innovation,* Research Policy, v. 45, 2, pp. 442-457, **TD No. 960 (April 2014).**

BURLON L. and M. VILALTA-BUFI, *A new look at technical progress and early retirement,* IZA Journal of Labor Policy, v. 5, **TD No. 963 (June 2014).**

BUSETTI F. and M. CAIVANO, *The trend–cycle decomposition of output and the Phillips Curve: bayesian estimates for Italy and the Euro Area,* Empirical Economics, V. 50, 4, pp. 1565-1587, **TD No. 941 (November 2013).**

CAIVANO M. and A. HARVEY, *Time-series models with an EGB2 conditional distribution,* Journal of Time Series Analysis, v. 35, 6, pp. 558-571, **TD No. 947 (January 2014).**

CALZA A. and A. ZAGHINI, *Shoe-leather costs in the euro area and the foreign demand for euro banknotes,* International Journal of Central Banking, v. 12, 1, pp. 231-246, **TD No. 1039 (December 2015).**

CESARONI T. and R. DE SANTIS, *Current account "core-periphery dualism" in the EMU,* The World Economy, v. 39, 10, pp. 1514-1538, **TD No. 996 (December 2014).**

CIANI E., *Retirement, Pension eligibility and home production,* Labour Economics, v. 38, pp. 106-120, **TD No. 1056 (March 2016).**

CIARLONE A. and V. MICELI, *Escaping financial crises? Macro evidence from sovereign wealth funds' investment behaviour,* Emerging Markets Review, v. 27, 2, pp. 169-196, **TD No. 972 (October 2014).**

CORNELI F. and E. TARANTINO, *Sovereign debt and reserves with liquidity and productivity crises,* Journal of International Money and Finance, v. 65, pp. 166-194, **TD No. 1012 (June 2015).**

D'AURIZIO L. and D. DEPALO, *An evaluation of the policies on repayment of government's trade debt in Italy,* Italian Economic Journal, v. 2, 2, pp. 167-196, **TD No. 1061 (April 2016).**

DE BLASIO G., G. MAGIO and C. MENON, *Down and out in Italian towns: measuring the impact of economic downturns on crime,* Economics Letters, 146, pp. 99-102, **TD No. 925 (July 2013).**

DOTTORI D. and M. MANNA, *Strategy and tactics in public debt management,* Journal of Policy Modeling, v. 38, 1, pp. 1-25, **TD No. 1005 (March 2015).**

ESPOSITO L., A. NOBILI and T. ROPELE, *The management of interest rate risk during the crisis: evidence from Italian banks,* Journal of Banking & Finance, v. 59, pp. 486-504, **TD No. 933 (September 2013).**

LIBERATI D., M. MARINUCCI and G. M. TANZI, *Science and technology parks in Italy: main features and analysis of their effects on hosted firms*, Journal of Technology Transfer, v. 41, 4, pp. 694-729, **TD No. 983 (November 2014).**

MARCELLINO M., M. PORQUEDDU and F. VENDITTI, *Short-Term GDP forecasting with a mixed frequency dynamic factor model with stochastic volatility,* Journal of Business & Economic Statistics , v. 34, 1, pp. 118-127, **TD No. 896 (January 2013).**

RODANO G., N. SERRANO-VELARDE and E. TARANTINO, *Bankruptcy law and bank financing,* Journal of Financial Economics, v. 120, 2, pp. 363-382, **TD No. 1013 (June 2015).**

ZINNA G., *Price pressures on UK real rates: an empirical investigation,* Review of Finance,v. 20, 4, pp. 1587-1630, **TD No. 968 (July 2014).**

2017

ADAMOPOULOU A. and G.M. TANZI, *Academic dropout and the great recession,* Journal of Human Capital, V. 11, 1, pp. 35–71, **TD No. 970 (October 2014).**

ALBERTAZZI U., M. BOTTERO and G. SENE, *Information externalities in the credit market and the spell of credit rationing,* Journal of Financial Intermediation, v. 30, pp. 61–70, **TD No. 980 (November 2014).**

ALESSANDRI P. and H. MUMTAZ, *Financial indicators and density forecasts for US output and inflation,* Review of Economic Dynamics, v. 24, pp. 66-78, **TD No. 977 (November 2014).**

BARBIERI G., C. ROSSETTI and P. SESTITO, *Teacher motivation and student learning,* Politica economica/Journal of Economic Policy, v. 33, 1, pp.59-72, **TD No. 761 (June 2010).**

BENTIVOGLI C. and M. LITTERIO, *Foreign ownership and performance: evidence from a panel of Italian firms,* International Journal of the Economics of Business, v. 24, 3, pp. 251-273, **TD No. 1085 (October 2016).**

BRONZINI R. and A. D'IGNAZIO, *Bank internationalisation and firm exports: evidence from matched firm-bank data,* Review of International Economics, v. 25, 3, pp. 476-499 **TD No. 1055 (March 2016).**

BRUCHE M. and A. SEGURA, *Debt maturity and the liquidity of secondary debt markets,* Journal of Financial Economics, v. 124, 3, pp. 599-613, **TD No. 1049 (January 2016).**

BURLON L., *Public expenditure distribution, voting, and growth,* Journal of Public Economic Theory,, v. 19, 4, pp. 789–810, **TD No. 961 (April 2014).**

BURLON L., A. GERALI, A. NOTARPIETRO and M. PISANI, *Macroeconomic effectiveness of non-standard monetary policy and early exit. a model-based evaluation,* International Finance, v. 20, 2, pp.155-173, **TD No. 1074 (July 2016).**

BUSETTI F., *Quantile aggregation of density forecasts,* Oxford Bulletin of Economics and Statistics, v. 79, 4, pp. 495-512, **TD No. 979 (November 2014).**

CESARONI T. and S. IEZZI, *The predictive content of business survey indicators: evidence from SIGE,* Journal of Business Cycle Research, v.13, 1, pp 75–104, **TD No. 1031 (October 2015).**

CONTI P., D. MARELLA and A. NERI, *Statistical matching and uncertainty analysis in combining household income and expenditure data,* Statistical Methods & Applications, v. 26, 3, pp 485–505, **TD No. 1018 (July 2015).**

D'AMURI F. and J. MARCUCCI, *The predictive power of google searches in forecasting unemployment,* International Journal of Forecasting, v. 33, 4, pp. 801-816, **TD No. 891 (November 2012).**

DE BLASIO G. and S. POY, *The impact of local minimum wages on employment: evidence from Italy in the 1950s,* Journal of Regional Science, v. 57, 1, pp. 48-74, **TD No. 953 (March 2014).**

DEL GIOVANE P., A. NOBILI and F. M. SIGNORETTI, *Assessing the sources of credit supply tightening: was the sovereign debt crisis different from Lehman?,* International Journal of Central Banking, v. 13, 2, pp. 197-234, **TD No. 942 (November 2013).**

DELLE MONACHE D. and I. PETRELLA, *Adaptive models and heavy tails with an application to inflation forecasting,* International Journal of Forecasting, v. 33, 2, pp. 482-501, **TD No. 1052 (March 2016).**

DEL PRETE S., M. PAGNINI, P. ROSSI and V. VACCA, *Lending organization and credit supply during the 2008–2009 crisis,* Economic Notes, v. 46, 2, pp. 207–236, **TD No. 1108 (April 2017).**

LOBERTO M. and C. PERRICONE, *Does trend inflation make a difference?,* Economic Modelling, v. 61, pp. 351–375, **TD No. 1033 (October 2015).**

MANCINI A.L., C. MONFARDINI and S. PASQUA, *Is a good example the best sermon? Children's imitation of parental reading,* Review of Economics of the Household, v. 15, 3, pp 965–993, **D No. 958 (April 2014).**

MEEKS R., B. NELSON and P. ALESSANDRI, *Shadow banks and macroeconomic instability,* Journal of Money, Credit and Banking, v. 49, 7, pp. 1483–1516, **TD No. 939 (November 2013).**

MICUCCI G. and P. ROSSI, *Debt restructuring and the role of banks' organizational structure and lending technologies,* Journal of Financial Services Research, v. 51, 3, pp 339–361, **TD No. 763 (June 2010).**

MOCETTI S., M. PAGNINI and E. SETTE, *Information technology and banking organization,* Journal of Journal of Financial Services Research, v. 51, pp. 313-338, **TD No. 752 (March 2010).**

MOCETTI S. and E. VIVIANO, *Looking behind mortgage delinquencies,* Journal of Banking & Finance, v. 75, pp. 53-63, **TD No. 999 (January 2015).**

NOBILI A. and F. ZOLLINO, *A structural model for the housing and credit market in Italy,* Journal of Housing Economics, v. 36, pp. 73-87, **TD No. 887 (October 2012).**

PALAZZO F., *Search costs and the severity of adverse selection,* Research in Economics, v. 71, 1, pp. 171-197, **TD No. 1073 (July 2016).**

PATACCHINI E. and E. RAINONE, *Social ties and the demand for financial services,* Journal of Financial Services Research, v. 52, 1–2, pp 35–88, **TD No. 1115 (June 2017).**

PATACCHINI E., E. RAINONE and Y. ZENOU, *Heterogeneous peer effects in education,* Journal of Economic Behavior & Organization, v. 134, pp. 190–227, **TD No. 1048 (January 2016).**

SBRANA G., A. SILVESTRINI and F. VENDITTI, *Short-term inflation forecasting: the M.E.T.A. approach,* International Journal of Forecasting, v. 33, 4, pp. 1065-1081, **TD No. 1016 (June 2015).**

SEGURA A. and J. SUAREZ, *How excessive is banks' maturity transformation?,* Review of Financial Studies, v. 30, 10, pp. 3538–3580, **TD No. 1065 (April 2016).**

VACCA V., *An unexpected crisis? Looking at pricing effectiveness of heterogeneous banks,* Economic Notes, v. 46, 2, pp. 171–206, **TD No. 814 (July 2011).**

VERGARA CAFFARELI F., *One-way flow networks with decreasing returns to linking,* Dynamic Games and Applications, v. 7, 2, pp. 323-345, **TD No. 734 (November 2009).**

ZAGHINI A., *A Tale of fragmentation: corporate funding in the euro-area bond market,* International Review of Financial Analysis, v. 49, pp. 59-68, **TD No. 1104 (February 2017).**

FORTHCOMING

ADAMOPOULOU A. and E. KAYA, *Young Adults living with their parents and the influence of peers,* Oxford Bulletin of Economics and Statistics, **TD No. 1038 (November 2015).**

ALBANESE G., G. DE BLASIO and P. SESTITO, *Trust, risk and time preferences: evidence from survey data,* International Review of Economics, **TD No. 911 (April 2013).**

BOFONDI M., L. CARPINELLI and E. SETTE, *Credit supply during a sovereign debt crisis,* Journal of the European Economic Association, **TD No. 909 (April 2013).**

CASIRAGHI M., E. GAIOTTI, L. RODANO and A. SECCHI, *A "Reverse Robin Hood"? The distributional implications of non-standard monetary policy for Italian households,* Journal of International Money and Finance, **TD No. 1077 (July 2016).**

D'AMURI F., *Monitoring and disincentives in containing paid sick leave,* Labour Economics, **TD No. 787 (January 2011).**

FEDERICO S. and E. TOSTI, *Exporters and importers of services: firm-level evidence on Italy,* The World Economy, **TD No. 877 (September 2012).**

GIACOMELLI S. and C. MENON, *Does weak contract enforcement affect firm size? Evidence from the neighbour's court,* Journal of Economic Geography, **TD No. 898 (January 2013).**

NATOLI F. and L. SIGALOTTI, *Tail co-movement in inflation expectations as an indicator of anchoring,* International Journal of Central Banking, **TD No. 1025 (July 2015).**

RIGGI M., *Capital destruction, jobless recoveries, and the discipline device role of unemployment,* Macroeconomic Dynamics, **TD No. 871 (July 2012).**

SEGURA A., *Why did sponsor banks rescue their SIVs?,* Review of Finance, **TD No. 1100 (February 2017).**