

The role of demographic dynamics in explaining asset returns:

Italy as a case study

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Abstract

The empirical connection between age-structure and asset returns has been so far investigated focussing mainly on the US. This paper aims to assess whether this connection is affected by a demographic dynamics steeper than the US one. The analysis is based on a simple OLG model and on the empirical investigation for Italy, which is experiencing one of the most pronounced ageing in the world. Following the approach used for the US, financial returns are regressed over demographic and/or control variables using annual data over 1958-2004. Results support the importance of the country-specific age-dynamics in explaining financial returns.

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1. Introduction

Pressures exerted by the demographic changes and specifically by the “baby boomers” on the various areas of an economy have been debated since the eighties. As they entered the labour market, worries were for a wider labour force that on one hand could have increased the unemployment rate and on the other reduced the wages. Recently, in view of their progressive ageing, the debate has shifted to financial economics and in particular on the link between age and financial asset returns¹, with the Asset Meltdown Hypothesis (AMH) being a notable example. Based on the life-cycle theory, the AMH is well summarized by Siegel 1998: “*Sell? Sell to Whom?*”. The rationale behind the AMH is that a larger working-age cohort drives up the demand for financial assets, accumulated to finance retirement, thereby exerting an upward pressure on asset prices. Conversely, the smaller cohort following a baby boom reduces the demand and faces the larger supply stemming from the retiring baby boomers. A downward pressure on asset prices naturally follows.

A number of theoretical models explore the possible link between demographic dynamics and financial asset returns. Poterba 2001 offers a starting point and models this relationship in a simplified overlapping generation (OLG) framework, in which an increase in the number of young workers drives up asset prices as both supply and the saving rate are fixed. This model rests on three main simplifying hypotheses: (i) the economy is closed, so that the different ageing processes across countries can not compensate via (integrated) financial markets; (ii) other possible economic implications of ageing (e.g. labour force and productivity rate changes) are disregarded the focus

¹ Particular attention has also been given to other implications of population ageing, e.g. on savings rates (see, among others, Adams and Prazmowski, 2003) or government fiscal policies and pension provisions (e.g. Schieber and Shoven 1997, Visco 2002, Bergstrom and Hartman 2005, Ludwig 2005 and Jimeno et al. 2007).

being only on the impact on financial markets; (iii) the saving rate and the capital supply are fixed.² Abel 2001 extends the model by Poterba 2001 in two ways: he allows a variable capital supply and includes the bequest motive concluding that the latter does not actually attenuate the AMH implications.³ Geanakoplos et al. 2004 consider the role of expectations: they show that if agents are myopic an increase in the size of middle-aged translates into a proportional increase in the stock prices, while if agents fully anticipate the demographic changes the increase is likely to be more than proportional. Even with further features of realism (e.g. business cycle shocks, uncertainty in wages and dividend), the final impact of demographic dynamics on stock prices varies only in terms of magnitude. In sum, these studies prove that a relationship between demographic dynamics and asset returns is plausible, but the magnitude and hence the importance of the possible implications for financial markets are not clear. This emphasises the role of the empirical studies, which up to date have taken different approaches.⁴ Yoo 1994 and Bellante and Green 2004 use cross-section regressions in which the share held in various kinds of assets is regressed on a set of explanatory variables measuring both demographic and non-demographic household characteristics (e.g. number of children, gender, race, education, income, wealth). The overall evidence supports a significant effect of demographic variables on portfolio choices and in particular of an inverse relationship between age and the share held in risky assets.

² The effect of the fixed-capital hypothesis is stressed by the same Poterba 2001, who in connection with the simulation results in Yoo 1994 writes: “a rise in the birth rate, followed by a decline, first raises then lowers asset prices” although “the effects are quite sensitive to whether or not capital is in variable supply. With a fixed supply of durable assets, asset prices in the baby boom economy rise to a height of roughly 35% above their level in the baseline case. This effect is attenuated, to a 15% increase in asset prices, in a production economy”.

³ In a subsequent work Abel 2003 considers a Social Security System (either PAYG, fully funded or a combination of the two), which affects the national savings and investments but does not influence the price of capital over the long run, as the latter increases in response to a baby boom but then follows a mean reverting behaviour.

⁴ For a survey on the empirical literature see, e.g. Brunetti 2007.

However, the most widespread approaches are based on time-series and panel regressions. In the former case, real returns on various kinds of financial assets (e.g. T-Bills, bonds and stocks) are generally regressed on a set of explanatory variables. The regression specifications however significantly vary across the contributions, ranging from analyses including demographic variables only (e.g. Yoo 1994, Poterba, 2004) to those considering also economic and financial variables (e.g. Davis and Li, 2003). The specifications may further differ because of the demographic measures used: mainly the average age (e.g. Erb et al. 1997, Goyal, 2004) or the age-classes percentages (e.g. Poterba 2001, 2004, Davis and Li, 2003). As far as panel regressions are concerned, a further distinction is needed, depending on the second dimension considered beside time: the household dimension (e.g. Guiso and Jappelli, 2001) or the country dimension (e.g. Erb et al., 1997).

The great diversification in the empirical works and the overall sensitivity of the findings to model calibration and/or econometric specification further motivate empirical analysis on this issue⁵, which in this paper is performed based on time-series regressions. Within this approach, the reference contribution is Poterba 2001: including only demographic regressors, the paper basically rejects the AMH for the US. The author motivates the result by observing that, during retirement, people disinvest assets much less rapidly than what life-cycle theory would suggest. Other papers have discussed different motivations for the results obtained by Poterba 2001: on one hand, Davis and Li 2003 consider the problems due to purely demographic specifications (i.e. omission of relevant “control” variables), on the other Abel 2001 relaxes the fixed-capital hypothesis.

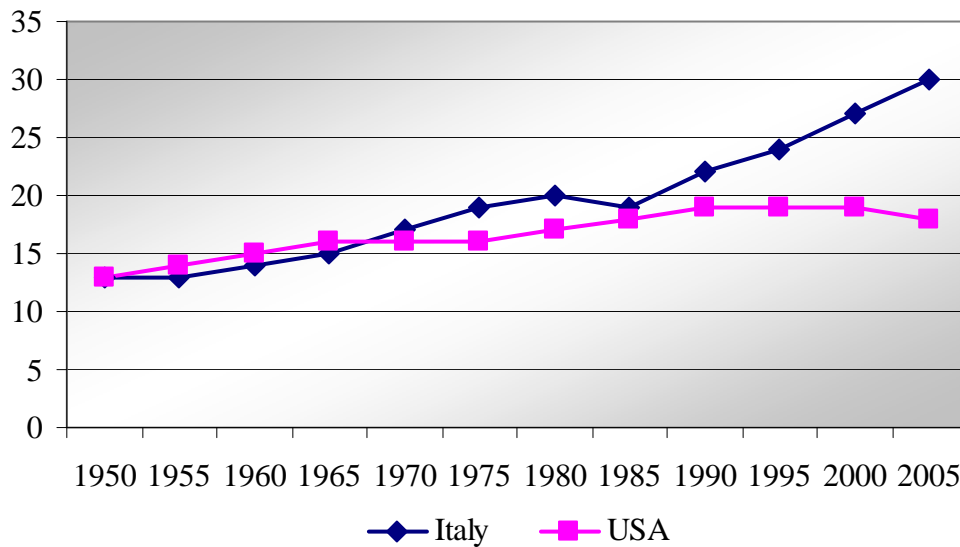
⁵ As Jimeno et al. 2007 put it: “the importance of demographic changes for asset returns and financial markets is still a disputable issue, on which more empirical evidence is needed”.

We believe that the dynamic pattern of the ageing phenomenon plays a fundamental role in determining the explanatory power of demographic variables. In particular, a steep demographic dynamics, which according to the life-cycle hypothesis would imply a strong unbalance between demand and supply of capital, is necessary in order to see the effects of demographic variables on financial returns

In this paper we first illustrate this idea by means of a stylized overlapping-generation (OLG) model and then we test it by taking Italy as a case study. Italy particularly lends itself to the empirical investigation since it is experiencing one of the strongest ageing dynamics in the world. In fact, it is much more marked than the US one, as emerges by looking for example⁶ at the old-dependency ratio dynamics in Chart 1: starting from the seventies the two old-dependency ratio dynamics depart from each other, with a sharp increase in the Italian one from the mid-eighties onwards. As for the methodology, we prefer a time-series approach which, as far as we know, has never been used so far to investigate the Italian case and allows comparison with most important studies for the US. First, we follow Poterba 2001, 2004 and estimate regressions in which demographic variables, i.e. the shares of different age-classes, explain real returns on different financial assets: corporate stocks, long-term government bonds and short-term government bonds (*Buoni Ordinari del Tesoro*, hereafter BOT). Then in line with Davis and Li 2003 we include non-demographic variables which may affect real equilibrium returns.

⁶ For a comparison of other demographic measures and details on the Italian case, see e.g. Brunetti and Torricelli 2007a.

Chart 1: Old-dependency ratio dynamics: comparison between Italy and US.



Note: the old-dependency ratio is the proportion of retirees, i.e. aged 65 or over, over the working-aged (between 15 and 64) population.
Data source: UN World Population Prospect.

The remainder of the paper is organized as follows. Section 2 develops a stylized model formalizing the link between demographic dynamics (rather than a demographic level) and asset prices. Section 3 and 4 describe the methodology, the dataset and the variables selected for the econometric analyses. Preliminary analyses are reported in Section 5, while Section 6 and 7 present the empirical results and compare the evidence for the Italian case with that for the US one. Section 8 concludes.

2. The Model

In this section we set up a stylized OLG model formalizing that the capital price is determined by the unbalances between its demand and supply, which are in turn affected by the dynamics of demographic changes. This contrasts with previous models where the level (rather than the dynamics) of a demographic factor plays a role in determining the capital price behaviour.

The general framework is as in Poterba 2001 and Abel 2001 but for the capital supply, which we assume to depend on the demographic structure. Specifically, we

assume a closed economy with identical individuals living two periods: when young they supply one unit of work and save a fixed rate of their unitary wage income (s), when old they retire and consume. The number of individuals born at the beginning of each period t is N_t , so that the aggregate saving in each period t is given by sN_t . On the other hand, the production is normalized to one, the aggregate capital stock does not depreciate over time and the price per unit of capital in each period t is equal to p_t .

Since all savings are used to purchase capital, it follows that:

$$p_t K_{t+1} = sN_t \quad (1)$$

where K_{t+1} is the aggregate capital stock to be carried into period t . According to Abel 2001, Equation (1) provides the demand for capital as a function of price, the number of young and the saving rate.

Given this “demand side” of the model, conclusions about the link between demographics and the capital price depend on the assumptions on the “supply side”.

If, as in Poterba 2001, a fixed capital supply is assumed ($K_{t+1} = K$), the price of capital in each period can be determined from (1) and it is proportional to the number of workers in that period, thus providing a link between the population age-structure and financial markets. It follows that a larger (smaller) cohort of young increases (decreases) the price of capital.

If, as in Abel 2001, the capital stock is assumed to grow at a gross rate which depends on the price of capital itself the analysis changes. In particular, Abel 2001 assumes the following capital supply curve:

$$K_{t+1} = \kappa K_t p_t^\lambda \quad (2)$$

where $\kappa, \lambda > 0$. Defining $\eta_{t+1} = \frac{N_{t+1}}{N_t}$ as the birth rate and solving simultaneously (1)

and (2), the following dynamics for the price of capital can be obtained:

$$\ln p_t = \frac{1}{1+\lambda} \ln p_{t-1} - \frac{1}{1+\lambda} \ln \kappa + \frac{1}{1+\lambda} \ln \eta_t \quad (3)$$

The demographic factors still plays a role in determining the price dynamics: an increase (decrease) in the birth rate η_t increases (decreases) the price of capital.

Abel 2001, stressing the “*important role of the supply of capital in determining the equilibrium price of capital*”, encourages the examination of alternative forms of variable aggregate capital supply. In this paper we want to model the role of the demographic structure in the accumulation of capital. To this end, we consider a capital supply curve in which the gross growth rate depends on both the capital price and the lagged birth rate⁷, i.e.:

$$K_{t+1} = \kappa K_t p_t^\lambda \eta_{t-1}^\xi \quad (4)$$

where the parameter $\xi \in \Re$ represents the sensitivity of the capital supply growth rate to demographic factor and hence describes the impact that a different demographic structure might have on capital accumulation. This functional form encompasses Abel 2001 and Poterba 2001 models and allows both results comparison and discussion over the existence and dimension of such an effect: if $\xi = 0$ there is no impact of

⁷ While the demand of capital in period (t, t+1) depends on people saving, i.e. those born in period t (N_t), the supply of capital is provided by those dissaving, i.e. those born in the previous period (N_{t-1}). For comparison with Abel 2001, we express the dependency in terms of the birth rate. Recalling that, given the born in previous period, the current birth rate is a positive linear function of the born in the current period, the dependency on η_{t-1} in equation (4) follows.

demographics on the supply and the model collapses into Abel's. If $\xi > 0$ ($\xi < 0$) a direct (inverse) relationship between birth rate and capital supply is defined.⁸

To solve the model, we first rewrite (4) as follows:

$$\frac{K_{t+1}}{N_{t+1}} = \kappa \frac{K_t}{N_t} \frac{N_t}{N_{t+1}} p_t^\lambda \eta_{t-1}^\xi \quad (5)$$

Letting $k_t = \frac{K_t}{N_t}$ be the capital-labour ratio and recalling the definition of η_{t+1} we get:

$$k_{t+1} = \kappa k_t \frac{1}{\eta_{t+1}} p_t^\lambda \eta_{t-1}^\xi \quad (6)$$

which represents the dynamics of capital for any given price level p_t . From (1) and (4)

we can get k_t as a function of p_t :

$$k_t = \frac{s}{\kappa} p_t^{-(1+\lambda)} \frac{1}{\eta_t^\xi} \quad (7)$$

Using (6) and (7) we find the equilibrium dynamics for the price of capital, i.e.:

$$\ln p_t = \frac{1}{1+\lambda} \ln p_{t-1} - \frac{1}{1+\lambda} \ln \kappa + \frac{1}{1+\lambda} \left[\ln \left(\frac{\eta_t}{\eta_{t-1}^\xi} \right) \right] \quad (8)$$

Equation (8) shows that capital price behaviour is affected by the dynamics of the demographic measure rather than by its level, as it is in Equation (3), which holds only if $\xi = 0$. More specifically, the capital price dynamics depends on demographic dynamics and the parameter ξ . Intuitively, the direction and dimension of the impact on capital prices depend on the interaction between the effects that the demographic factor

⁸ While the link between age-structure and capital accumulation is widely accepted in the literature, no unanimous conclusion has been reached concerning its nature. This arises from the multiplicity of mechanisms underlying this relationship, which may go beyond the savings behaviour and the experience-based human-capital mechanism, as argued by Lindh and Malmberg 1999. In addition, the effects of demographic transitions on savings are not clear a priori (see e.g. Cutler et al., 1990) and in the empirical studies the results might depend on the assumptions made and the scenarios considered (e.g., see Gonand, 2005). Finally, even assuming a positive effect of younger population on savings, D'Albis 2007 proves that population growth rate and capital per capita may have a non-monotonic relationship.

has on the demand with those that the very same factor has on the supply of the capital and in particular on the possible unbalance between the two. Consider for example $\xi = 1$: under a balanced demographic dynamics, i.e. $\eta_t \approx \eta_{t-1}$, there would be no or negligible effects on the asset prices. On the other hand, with a stronger demographic dynamics the final effect on asset prices may be much more relevant.⁹ In particular, if $\eta_t < \eta_{t-1}$ (i.e. a progressively ageing population) the model implies a negative pressure on asset prices, while the opposite is true in case of a positive dynamics for the birth rate.

To sum up, the model presented highlights the role that a marked demographic dynamics might have in affecting asset prices behaviour. This result can explain the differences in the empirical evidence between countries experiencing a smooth demographic dynamics (such as the US) and countries with steeper ageing dynamics (such as Italy). In order to empirically test this implication, we perform with Italian data the same type of empirical tests used to analyse the US case and discuss whether the different results can be explained in terms of the different ageing pattern.

3. The Regressions

The link between the evolution of population age-structure and financial asset returns is tested by estimating a sequence of linear regressions in which measures of demographic age-structure are included as explanatory variables. The regression specifications are defined in line with the relevant literature for the US, in order to compare results. First, in line with Poterba 2001, 2004 the following regression is estimated:

⁹ Obviously, the exact definition of the process for the asset prices depends on the process for η_t , which can be taken depending on the country-specific characteristics of the demographic evolution.

$$R_t = \alpha + \beta \mathbf{D}_t + \varepsilon_t \quad (9)$$

where R_t is the real return on either stocks, long-term government bonds or BOT, \mathbf{D}_t is the vector of demographic variables and ε_t represents the error term. A purely demographic specification such as (9) is likely to be affected by the problem of omitted variables: stock and bond returns are plausibly driven by other forces than demographic dynamics, as the very same Poterba 2004 stresses: “*A key limitation of [...] the previous empirical analysis on demography and asset returns is that it does not embed the analysis in a broader model of equilibrium asset return determination. As such, the equations lack control variables that might reduce the omitted variable problem.*” Based on the latter observation, we follow Davis and Li 2003 and estimate an extended version of (9), i.e.:

$$R_t = \alpha + \beta \mathbf{D}_t + \gamma \mathbf{F}_t + \varepsilon_t \quad (10)$$

where \mathbf{F}_t represents the economic and financial variables included as control ones. To further test the relevance of demographic dynamics on financial market returns, we drop the demographic variables and check whether the following specification:

$$R_t = \alpha + \gamma \mathbf{F}_t + \varepsilon_t \quad (11)$$

produces poorer results in terms of both estimation output and diagnostic tests.

4. Dataset and variables selection

The main point in this type of empirical work is the selection of both demographic and economic-financial variables, which has to trade off between sensible theoretical underpinnings on one hand and specific features of the Italian case and data availability on the other.

The dataset is obtained by merging both demographic and economic-financial data: the former draw from the Eurostat demographic database, the latter either from the IMF International Financial Statistics or Datastream. The dataset contains annual observations spanning over the period 1958-2004 except for dividend-yield and BOT, respectively available starting from 1973 and 1981. Both the frequency and the time span of the dataset are constrained by data availability. In fact, demographic data are not available at a frequency higher than the annual one and economic-financial data, obtainable also at higher frequencies, are accessible only from the late 1950s. Moreover, financial variables are typically highly volatile while demographic ones are generally slowly varying: as a result, the actual relationship between these two kinds of variables can be detected only over the long run.¹⁰ Based on this argument some authors have performed estimations using multi-period variables (see e.g. in Bosworth et al., 2004). In the following analyses we prefer annual data both to maintain a sample size which guarantees statistically significant results and to allow consistency with most recent papers, included Davis and Li 2003 and Poterba 2004.

The dependent variables are the real returns on three financial assets differing for riskiness and maturity: (i) stocks, R_t^{STOCK} ; (ii) long-term (10 years) government bonds, R_t^{BOND} ; and (iii) short-term (12-month)¹¹ government bonds, R_t^{BOT} . Yields on long-term bonds are directly available, while equity returns have to be calculated: in line with the literature, the continuously compounded rate of return of the Italian Share Price Index is used. Similarly, the annual yield on 12-month BOT is derived as from the

¹⁰ For the econometric problems entailed by low frequency financial data see, e.g., Campbell et al. 1996.

¹¹ Alternatively, the 3-month BOT could have been chosen. Yet, as this kind of interest rate is typically (directly or indirectly) driven by monetary policy interventions (among others see Favero, 2006) 12-month BOT have been preferred.

annual average BOT issue prices. For each asset, real returns are worked out by using the Consumer Price Index.

The demographic variables included in the models are selected in line with the existing empirical works.¹² In estimating model (9) we follow Poterba 2004 and use either the shares of late working-aged and elderly on the entire population (Pop_t^{40-64} and Pop_t^{65+}) or the shares of the same age-classes over the adult population, aged 20 or over ($Pop_t^{40-64/20+}$ and $Pop_t^{65/20+}$). By contrast, when the extended regression specification is tested, we follow Davis and Li 2003 and include first the shares of early and late working-aged over the entire population (Pop_t^{20-40} and Pop_t^{40-64}) and then also the shares of retirees (Pop_t^{65+}).¹³ Table 1 summarizes the expected signs that the demographic variables should theoretically display in each asset return regression, assuming a fixed supply of each asset and no international capital flows.¹⁴ These signs rest on risk-aversion and investment-horizon arguments. As for the former, age is directly linked to risk aversion, so that a wider share of young, more risk-loving, is going to increase the aggregate demand for riskier activities, such as stocks, thereby increasing their prices and hence their relative returns. The demand for riskier activities from working-aged might also be fostered by the need to accumulate assets for

¹² In assessing the link between demographics and financial market, some authors (e.g. Goyal 2001), Ang and Maddaloni, 2005 use demographic variables in first differences, while others (e.g. Brooks 2002, Poterba, 2001, 2004, Davis and Li, 2003) use levels. Here the second approach is preferred for comparability with the results for the US.

¹³ This is the standard age-class partition generally used in the empirical literature. Since the ending points of the working-age might differ across countries, the analyses have been also performed using slightly different age-classes, better matching the specific features of Italian labour market. Results (available upon request) are basically consistent with those obtained with the standard age-classes.

¹⁴ Several works (e.g. Börsch-Supan et al., 2006) highlight the relevance of the link between demographics and international capital flows. Yet, in this study the no-international capital flows assumption is maintained because it allows direct comparability with the cited literature and, for most of the period considered, it represents a suitable assumption for the Italian case.

retirement (precautionary savings).¹⁵ Specifically for the Italian case, the latter argument is particularly interesting as the recent social security reform has introduced the need for a second, e.g. collective pension funds, and third pillar, e.g. life insurances and individual participation to open pension funds.¹⁶ Based on the same rationale, elderly tend to prefer safer rather than risky assets so that an older population might result in a downward pressure on the prices and hence of on the returns of riskier assets. Beside, age is inversely related to the investment horizon, so that an ageing population is likely to reduce the demand for assets such as long-term government bonds. As the middle-age class is quite vast, the expected signs may be somewhat undetermined depending on which of the above cited effects really prevails.

Table 1: Demographic variables: expected signs.

	Pop_t^{20-40}	Pop_t^{40-64}	Pop_t^{65+}
Stocks	+	+/-	-
Bonds	-	+/-	+
BOT	+	+/-	-

Turning to control variables, for the stock return regressions we follow Davis and Li 2003 and rest on Gordon 1962 model, which basically states that under the hypothesis of constant dividend growth rate, real long rate and risk premium, the equity price is given by the discounted value of all future dividends. Hence, the control variables included in the regression for equities are: the lagged dividend yield (DY_{-1}), the real long-term interest rate (r), the log of the share price volatility (VOL), the trend of

¹⁵ On precautionary motive and portfolio choices see e.g. Hochguertel 2003.

¹⁶ The Italian pension system has been soundly reformed starting from the beginning of the nineties by means of a series of interventions, the most important being the 1995 Dini Reform. For a full description of the restructuring process see e.g. Baldacci and Tuzi 2003.

the GDP growth rate (g)¹⁷ and the difference between GDP growth rate and g (Gap). The volatility is included as a proxy of the risk premium¹⁸, while the lagged dividend yield and g are included to proxy for the initial level and average growth rate of dividends. Finally, Gap is included based on the observation that, besides the trend growth of GDP, share prices can also be affected, although only temporary, by cyclical fluctuations of GDP. The expected sign of the coefficients of dividend yield and GDP growth trend are not clear: on one hand, they could be positively signed since higher expected dividends entail higher stock values; on the other, they could be negatively signed since when the dividend is paid, the value of the stock is reduced by this value. The possible impact of real interest rate is also unclear: on one hand an increase in the interest rates might suggest an increase in the expected growth rates of the whole economy, thereby pushing up the expected gains from stocks and hence the relative returns; on the other, a higher interest rate reduces the discounted value of the future dividends, thereby shrinking the stock prices and the relative returns. By contrast, both volatility and output gap are expected to unambiguously and positively affect the equity returns: the former based on the risk-return theory, the latter based on the argument that higher (lower) than expected real GDP growth might boost (reduce) stock prices and returns.

As for both long and short-term government bonds, we follow Davis and Li 2003 and derive the control variables to include in the regression specification based on the expectation theory of the term-structure (EH). The following variables are thus included: Δsr , the change in the short-rate; $Spread_{-1}$, the lag of the term spread (only

¹⁷ g is obtained by applying the Hodrick Prescott filter (smoothing factor of 100) on the log difference of real GDP.

¹⁸ Data for Italian Share Price Index volatility are not directly available and are thus computed as the standard deviation of the last 12 monthly observations.

for long-term government bonds); π_{-1} and $\Delta\pi$, the lag and the percentage variation of inflation; g and Gap , defined as above. Based on EH, the expected signs for both Δsr and $Spread_{-1}$ are positive. The same holds for the GDP variables, as higher GDP growth is generally expected to increase the interest rates of the economy, therefore increasing the government bond yields. Conversely, inflation-related variables should turn out negatively signed in the light of the Fisher equation.

In estimating models (10) and (11) for stock returns, the volatility and the GDP-related variables (g and Gap) are included with a one-period lag. Similarly, when (10) and (11) are estimated for long-term government bond yields, lagged rather than current GDP-related variables are included. The rationale behind these choices is that the impact of these variables normally realizes with some delay since data on GDP are released with a certain delay and volatility is generally not immediately fully perceived by financial market agents.¹⁹ On the other hand, when estimating the models for BOT, the GDP variables are included in current rather than in lagged levels based on the fact that short-term rates are generally influenced by monetary policy interventions which are generally set according to the current economic condition.

5. Descriptive statistics and preliminary analyses

As a preliminary analysis, the stationarity of variables is tested by means of the Augmented Dickey-Fuller (ADF) test. Then, all the regressions are estimated with OLS and the standard diagnostic tests are run to check whether the underlying hypotheses of the linear regression model are fulfilled. More specifically, residual autocorrelation is tested by means of Durbin-Watson (DW) for 1st order and by means of the Ljung-Box

¹⁹ As a test, the models have also been estimated including the current rather than the lagged values of both GDP-related variables and volatility. The overall poorer results supported this sort of slow response of financial markets to these variables.

test for higher order (up to 4th).²⁰ The homoskedasticity, normality and stationarity of the residuals are tested by means of the White's Heteroskedasticity Test, Jarque-Bera statistic and ADF test respectively²¹. In case of heteroskedastic and autocorrelated residuals, the model is estimated imposing Newey and West 1987 consistent covariances. In addition, the Chow forecast test is run to check for stability of coefficients before and after 1995, chosen as possible structural break in the light of the major social security reform, known as the Dini Reform, which marked the shift from an earning-based (defined benefits) to a contribution-based (defined contribution) pension system in Italy. RESET (with 3 fitted terms) is also run to test for general specification errors. Finally, when all demographic variables in the model specification are found statistically significant, a Wald test is run to further test their joint significance.

Table 2 reports the main descriptive statistics and the results for the ADF stationarity test for the three dependent variables. All dependent variables appear stationary as the null of unit root can be rejected at least at the 5% level of significance.

Table 2: Dependent variables: descriptive statistics and ADF tests.

	STOCK	BOND	BOT
Observations	47	47	24
Mean	0.0202	0.0268	0.0420
Median	-0.0493	0.0324	0.0473
Max	0.6576	0.0811	0.0896
Min	-0.4516	-0.0726	-0.0037
Std. Dev.	0.261032	0.0324	0.0244
t-Statistic	-5.4117***	-2.4357**	-3.5040**

*Notes: the ADF tests are run assuming a constant and *, ** and *** denote significance at 10%, 5% and 1% respectively.*

²⁰ Davis and Li 2003) use instead the Breusch-Godfrey Lagrange Multiplier (LM) test setting the highest order of serial correlation to test equal to 2. The LM is however an asymptotic test; hence, in the light of the limited sample size, the Ljung-Box is here preferred.

²¹ In testing the stationarity of the regression residuals, the ADF statistics are evaluated using appropriate critical values, as from e.g. Davidson and MacKinnon 1993.

Results of stationarity tests for independent variables are reported in Table 3. All control variables turn out to be stationary at conventional significance level. Note that the unit-root test for inflation is run isolating the period during which the inflation rate jumped as a consequence of the two oil shocks. As for the demographic variables, both early and late working-aged shares appear stationary at least at a 10% level of significance while the null of unit-root is strongly accepted for the shares of the elderly, which is unsurprising given the strong population ageing in Italy (see e.g. Brunetti and Torricelli, 2007a).

Table 3: Explanatory variables: ADF tests.

Variables		HP	t-Statistic	Prob.	
Control	<i>DY</i>	Constant	-3.785	0.0316	
	<i>g</i>	Constant and Trend	-3.965	0.0002	
	<i>Gap</i>	Constant	-4.590	0.0007	
	<i>Spread</i>	Constant	-3.197	0.0266	
	<i>Vol</i>	Constant and Trend	-4.908	0.0013	
	Δsr	Constant	-7.147	0.0000	
	π		Constant, 1959-1973	-3.603	0.0235
			Constant, 1974-1985	-3.399	0.0311
			Constant, 1986-2004	-2.893	0.0638
Demographic	20 - 39	Constant and Trend	-3.377	0.0765	
	40 - 64	Constant and Trend	-3.310	0.0777	
	40-64/20+	Constant and Trend	-5.630	0.0002	
	65+	Constant and Trend	-2.365	0.3918	
	65+/20+	Constant and Trend	-2.846	0.1893	

Note: according to Hamilton 1994, the ADF tests are run assuming either a constant or a constant and a trend.

6. A purely demographic specification

In order to allow a direct comparison with Poterba 2004, model (9) is estimated by including only two demographic variables as explanatory ones: the shares of late middle-aged and retired people computed either over the entire or over the adult (aged

more than 20) population.²² The results obtained are compared with those for the US reported in Poterba 2004 for the period 1947-2003 (see Table 4). As in the latter study, the adjusted R² is reported to evaluate the model. In addition, the standard diagnostic tests are reported in order to detect any possible statistical weakness of the estimated models.

Table 4: Results for stock returns: US and Italy.

	Poterba 2004, US: 1947 – 2003		This Study, Italy: 1958 – 2004	
Constant	N/A	N/A	2.042 (1.984)	3.740** (1.842)
Pop_t^{40-64}	3.428 (2.146)	-	-9.019 (8.379)	-
Pop_t^{65+}	1.716 (1.477)	-	4.871 (4.175)	-
$Pop_t^{40-64/20+}$	-	0.155 (0.977)	-	-8.456** (4.051)
$Pop_t^{65+/20+}$	-	0.731 (1.577)	-	-1.352 (1.404)
Adjusted R ²	0.023	-0.035	-0.013	0.051
DW	N/A	N/A	1.307	1.391
Ljung-Box	N/A	N/A	8.499*	8.321*
White Test	N/A	N/A	2.014	0.329
Jarque-Bera	N/A	N/A	1.121	1.680
ADF	N/A	N/A	-4.613***	-4.848***

*Note: the upper panel reports for each demographic variable the estimated coefficient (standard errors in parenthesis) as from Poterba 2004 and this study. The lower panel reports main diagnostic tests on the residuals: Durbin-Watson (DW) for 1st order and Ljung-Box for up to 4th order residual autocorrelation, White's heteroskedasticity test, Jarque-Bera statistics for normality and ADF for stationarity. *, ** and *** denote significance at 10%, 5% and 1% respectively.*

Consistently with Poterba 2004, Italian data suggest that none of the demographic variables is statistically relevant in driving the real returns on stocks. Diagnostic tests however highlight serially-correlated residuals, which in this case

²² Despite the non-stationarity of the retired variables, which in fact makes the regression unbalanced, the results obtained are presented anyway for comparability sake. Furthermore, as Maddala and Kim (1998) put it: “Should one estimate unbalanced regressions? Of course not, if it can be avoided. But if it has to be done, one has to be careful in their interpretation [...]”

might plausibly indicate on an omitted-variable problem. Interestingly, when the same model is estimated using the shares over the adult population results depart from Poterba 2004: the share of late middle-aged over the adult population turns statistically significant and the adjusted R^2 is significantly higher. Furthermore, the signs contrast those in Poterba 2004: the negative sign of those aged between 40 and 64 suggests that in Italy this is a life-cycle phase in which the agents start to abandon risky investments such as equities, thereby reducing their prices and hence the relative returns.

Table 5: Results for bonds yields: US and Italy.

	Poterba 2004, US: 1947 – 2003		This Study, Italy: 1958 – 2004	
Constant	N/A	N/A	-0.845*** (0.238)	0.585** (0.248)
Pop_t^{40-64}	-0.585 (1.356)	-	3.580*** (1.101)	-
Pop_t^{65+}	2.335** (0.933)	-	-1.495*** (0.501)	-
$Pop_t^{40-64/20+}$	-	-0.697 (0.602)	-	-1.289** (0.544)
$Pop_t^{65+/20+}$	-	1.327 (0.971)	-	-0.112 (0.189)
Adjusted R^2	0.091	0.085	0.224	0.1297
DW	N/A	N/A	0.554	0.471
White Test	N/A	N/A	1.767	1.775
Jarque-Bera	N/A	N/A	8.637**	5.315*
ADF	N/A	N/A	-3.498**	-3.199*
Ljung-Box	N/A	N/A	32.686***	48.057***

Note: same as Table 4.

As for bonds, Poterba 2004 reports “*weak evidence that in the fixed income markets, and particularly the Treasury bill market, population age structure is correlated with asset returns*” (Table 5). With Italian data, both demographic variables turn out statistically significant, but also in this case the estimated model shows non-stationary and serially-correlated residuals, suggesting again the possibility of omitted variables. When the analysis is repeated using the shares over the adult population,

results are poorer for both the US and Italy: in Poterba 2004 none of the demographic variables is statistically relevant, while in the Italian case only the share of late working-aged appears significant. Furthermore, also in this case, the severe serial correlation of the residuals point to an apparent statistical weakness of this model.

Table 6: Results for short-term government bonds: US and Italy.

	Poterba 2004, US: 1947 – 2003		This Study, Italy: 1981 – 2004	
Constant	N/A	N/A	-0.521 (0.345)	1.332*** (0.245)
Pop_t^{40-64}	-0.311 (0.372)	-	2.604* (1.342)	-
Pop_t^{65+}	1.003*** (0.256)	-	-1.599*** (0.514)	-
$Pop_t^{40-64/20+}$	-	0.077 (0.158)	-	-2.252*** (0.490)
$Pop_t^{65+/20+}$	-	1.120*** (0.255)	-	-1.793*** (0.253)
Adjusted R ²	0.236	0.296	0.406	0.698
DW	N/A	N/A	0.372	0.817
White Test	N/A	N/A	1.755	0.949
Jarque-Bera	N/A	N/A	0.600	2.335
ADF	N/A	N/A	-1.442	-3.424**
Ljung-Box	N/A	N/A	30.941***	7.3513*

Note: same as Table 4.

Table 6 compares the results for real returns on US T-Bills and in Italian BOT. Consistently with Poterba 2004 this is the case in which the purely demographic specification reveals the most significant evidence of a relationship between demographics and financial return dynamics since the model fits real data much better than in the previous cases. Specifically, for the Italian case, both demographic variables are strongly significant regardless of the shares being computed over the entire or over the adult population. Yet, the results are not robust across the two variants considered: using the shares over the entire population, the coefficients display signs consistent with the expectation (i.e. positive for late middle-aged and negative for retirees); by contrast,

when the shares over the adult population are used both variables turn out negatively signed. Furthermore, also the results for BOT have to be interpreted with caution since the residuals are not always stationary and are highly correlated, suggesting the risks of omitted variables or of spurious regression.

To sum up, compared to what Poterba 2004 reports for the US, the evidence for the Italian case is overall more supportive of the role of demographics in financial markets. On the other hand, results are not always fully consistent with expectations and across the variants estimated. Furthermore, the unbalanced regression specification (due to the non-stationarity of the over-65 variables) and the plausible omitted-variable problem claim for particular caution in interpreting these results. Hence, in the next Section the regression model specification will be accordingly adjusted to take these features into account.

7. An extended specification

Findings presented in this Section are based on a regression specification that includes the economic-financial variables selected as described in Section 4. Results are first presented for stocks, long-term government bonds and BOT separately. Then, Section 7.4 provides a comparison between the findings for Italy and those reported by Davis and Li 2003 for the US.

7.1 Results for stocks

Panel I of Table 7 reports the estimation output for the following regression:

$$R_t^{STOCK} = \alpha + \beta_1 Pop_t^{20-39} + \beta_2 Pop_t^{40-64} + \beta_3 g_{t-1} + \beta_4 Gap_{t-1} + \beta_5 r_t + \beta_6 Vol_{t-1} + \beta_7 DY_{t-1} + \varepsilon_t \quad (10a)$$

and shows that both demographic variables are statistically significant and, together with economic-financial ones, can explain more than 43% of the variation in the real returns on equities over the sample period. Among control variables, the long-term

interest rate and the GDP trend growth rate are the only statistically significant, both displaying negative signs. While for the former this is in line with the theory, the negative sign of GDP trend growth rate might stem from the fact that higher GDP generally inflates interest rates, thereby reducing the real returns on stocks via a downward pressure on firm investments coupled with a higher discount factor for future dividend flows.²³ The non-significant coefficient of volatility might be due to the fact that the latter may not be the best proxy for risk premium.²⁴ Turning to demographic variables, while the estimated coefficient for early working-aged is significant only at a 10% significance level, that for late working-aged appears strongly significant. Both coefficients are correctly signed and, being quite high in magnitude, point towards a strong impact of demographic dynamics on stock real returns. More specifically, the proportion of early working-aged tends to increase the returns on equities, while that of late working-aged seems to have the opposite effect. This result is consistent with Brunetti and Torricelli (2007a) who find that, on average, Italian middle-aged households hold riskier portfolios while older ones tend to disinvest risky financial instruments and turn to safer ones. The residuals pass all diagnostic tests, thus validating the inference on the estimated results.

²³ Recall that the GDP growth rate may not be the best proxy for dividend growth rate. Davis and Li (2003) for instance argue that the industrial production index could be a suitable alternative. This variant has also been examined, but basically led to similar results (available upon request).

²⁴ There is a debate on the most appropriate proxies for risk-premium, which however goes beyond the scope of this work: on this issue see e.g. Mehra and Prescott (1985), Welch (2000) and Jones and Wilson (2005).

Table 7: Results for real returns on stocks, 1973-2004.

Variable	PANEL I Model (10a)		PANEL II Model (10a')		PANEL III Model (11a)	
	Coefficient	S.e.	Coefficient	S.e.	Coefficient	S.e.
α	4.931*	2.532	1.771	3.246	0.945**	0.364
Pop_t^{20-39}	11.161*	5.711	17.601*	9.333	-	-
Pop_t^{40-64}	-22.489**	10.665	-11.452**	5.515	-	-
Pop_t^{65+}	-	-	-11.504**	5.291	-	-
g_{t-1}	-39.918***	6.652	-51.329***	9.785	-26.991***	8.812
Gap_{t-1}	1.843	1.948	2.610	1.855	1.345	2.234
r_t	-6.150***	1.402	-9.910***	2.800	-3.963*	2.179
Vol_{t-1}	-0.034	0.048	-0.023	0.044	-0.067***	0.024
DY_{t-1}	0.007	0.012	0.005	0.012	0.004	0.012
R^2	0.435		0.509		0.369	
Adjusted R^2	0.263		0.331		0.243	
DW	1.893		2.255		1.861	
Tests	Stat.	Prob.	Stat.	Prob.	Stat.	Prob.
F-statistic	2.533	0.044	2.853	0.024	2.922	0.033
Ljung-Box	1.372	0.849	3.356	0.500	3.451	0.485
Homoskedasticity	1.398	0.258	0.983	0.517	0.822	0.613
Normality	1.469	0.480	1.627	0.443	0.061	0.970
Unit root	-5.223**	-	-5.146**	-	-5.012**	-
Wald	10.516	0.005	5.143	0.076	-	-
RESET (3)	0.909	0.454	1.929	0.159	0.183	0.907
Chow (1995)	1.969	0.126	1.679	0.196	1.636	0.188

Note: *, ** and *** denote 10%, 5% and 1% level of significance

Following Davis and Li 2003, the robustness of the results is tested by estimating the model including also the shares of the elderly (see Panel II of Table 7):

$$R_t^{STOCK} = \alpha + \beta_1 Pop_t^{20-39} + \beta_2 Pop_t^{40-64} + \beta_3 Pop_t^{65+} + \beta_4 g_{t-1} + \beta_5 Gap_{t-1} + \beta_6 r_t + \beta_7 Vol_{t-1} + \beta_8 DY_{t-1} + \varepsilon_t \quad (10a')$$

The increased adjusted R^2 proves that the inclusion of the retirees actually adds information to the estimated model, indicating the significant role that the share of the elderly might play in affecting the Italian stock market. On the whole, the results obtained are consistent with those for model (10a) and, as above, the residuals of this model pass all the diagnostic tests. Among control variables, GDP trend growth rate and real long-term interest rate are the only statistically significant and have the same signs

as in the previous case. Furthermore, according with expectations the estimated coefficient for Pop_t^{65+} is negative.

The relevance of the demographic variables is further proved by the poorer results obtained when the latter are omitted (see Table 7, Panel III):

$$R_t^{STOCK} = \alpha + \beta_1 g_{t-1} + \beta_2 Gap_{t-1} + \beta_3 r_t + \beta_4 Vol_{t-1} + \beta_5 DY_{t-1} + \varepsilon_t \quad (11a)$$

Since (11a) is nested in (10a) and (10a'), the comparison is done on the basis of adjusted R^2 : the purely economic-financial specification reaches a 24.3% which is in fact lower than the 26.3% and 33.1% respectively observed in the two previous models. Yet, the diagnostic tests still state the statistical validity on this model.

On the whole, the evidence found across all the variants estimated highlight a relevant role of the age-structure of the population in explaining the real returns on stocks. In addition, the estimated coefficients of the demographic variables display signs in line with the life-cycle theory, suggesting a positive (negative) effect of the share of early (late) working-aged on the stocks real returns.

7.2 Results for long-term government bonds

The impact of a change in the demographic structure of the population on long-term government bond yields is assessed by estimating the following regression (see Panel I of Table 8):

$$R_t^{BOND} = \alpha + \beta_1 Pop_t^{20-39} + \beta_2 Pop_t^{40-64} + \beta_3 \Delta sr_t + \beta_4 Spread_{t-1} + \beta_5 \pi_{t-1} + \beta_6 \Delta \pi_t + \beta_7 g_{t-1} + \beta_8 Gap_{t-1} + \varepsilon_t \quad (10b)$$

The residuals are stationary and normally distributed but display both heteroskedasticity and autocorrelation, so that the model is re-estimated with Newey-West consistent standard errors. The RESET and the Chow test respectively accept the null of no misspecification and of coefficient stability before and after 1995 at a 5% level of

significance. All control variables but those GDP-related are statistically significant and, among the demographic ones, only the share of early working-aged seems to affect the bond yield dynamics. As expected, inflation seems to reduce the real bonds yields. In addition, the coefficients associated with inflation variables are among the highest and most strongly significant among those estimated: the rationale could rely on the fact that the period under analysis includes episodes of very high inflation movements, such as those following the two oil shocks between the end of 70s and the beginning of 80s. By contrast, the terms spread coefficient, which should be positively signed based on the expectation theory of the term structure, is negatively signed. This may stem from a mean reverting behaviour of the term structure: when the spread is too high, the monetary policy authorities may reduce short rates so that the expected future short rates decrease, thereby reducing the long-term interest rates.²⁵ As for the demographic variables, the share of early working-aged is significant and signed as expected, while that for late working-aged instead is not statistically relevant, suggesting that this portion of the population does not really affect the dynamics of long-term government bonds yields.

The variant including the shares of the elderly leads to the estimation of the following model:

$$\begin{aligned}
 R_t^{BOND} = & \alpha + \beta_1 Pop_t^{20-39} + \beta_2 Pop_t^{40-64} + \beta_3 Pop_t^{65+} + \beta_4 \Delta sr_t + \beta_5 Spread_{t-1} + \\
 & + \beta_6 \pi_{t-1} + \beta_7 \Delta \pi_t + \beta_8 g_{t-1} + \beta_9 Gap_{t-1} + \varepsilon_t \quad (10b')
 \end{aligned}$$

The Panel II of Table 8 reports the estimation output and diagnostic tests. Except for homoskedasticity and serial correlation, the residuals fulfil the usual assumption and the stability tests provide evidence of no misspecification and of coefficient stability at a

²⁵ Evidence of a mean reverting term structure of Italian interest rates is also found in Brunetti and Torricelli 2007b.

5% level of significance. According to the results, the share of the early working-aged turns out to be the only one actually affecting the real returns on long-term bond yields. This is sensible from a theoretical point of view, as a higher share of young investors pushes up the demand for long-term bonds, increasing their prices and reducing their returns. By contrast, late working-aged and retirees seem not to play a significant role in affecting the course of long-term government bonds yields, possibly due to the investment horizon of these assets, which is uninteresting to them.

Table 8: Results for long-term government bond yields, 1958 - 2004.

Variable	PANEL I Model (10b)		PANEL II Model (10b')		PANEL III Model (11b)	
	Coefficient	S.e.	Coefficient	S.e.	Coefficient	S.e.
α	0.347	0.404	0.395	0.320	0.058***	0.015
Pop_t^{20-39}	-1.063**	0.480	-1.021***	0.385	-	-
Pop_t^{40-64}	0.230	0.864	-0.065	0.849	-	-
Pop_t^{65+}	-	-	0.298	0.415	-	-
Δsr_t	0.375**	0.185	0.318*	0.179	0.345*	0.175
$Spread_{t-1}$	-0.399**	0.166	-0.414***	0.123	-0.643***	0.217
π_{t-1}	-0.598***	0.176	-0.661***	0.151	-0.301***	0.092
$\Delta\pi_t$	-1.126***	0.162	-1.140***	0.186	-1.007***	0.169
g_{t-1}	-0.754	0.554	-0.791	0.516	-0.045	0.301
Gap_{t-1}	0.003	0.034	0.000	0.037	0.008	0.038
R^2	0.808		0.882		0.684	
Adjusted R^2	0.751		0.836		0.630	
DW	0.901		1.227		0.729	
Tests	Stat.	Prob.	Stat.	Prob.	Stat.	Prob.
F-statistic	14.216	0.000	19.154	0.000	12.640	0.000
Ljung-Box	35.453	0.000	38.250	0.000	36.128	0.000
Homoskedasticity	2.498	0.030	2.281	0.061	1.423	0.211
Normality	1.322	0.516	1.136	0.567	1.733	0.420
Unit root	-4.631*	-	-4.700**	-	-4.025**	-
Wald	-	-	-	-	-	-
RESET (3)	1.769	0.173	1.859	0.167	3.096	0.059
Chow (1995)	2.107	0.085	2.386	0.073	3.311	0.007

Note: *, ** and *** denote 10%, 5% and 1% level of significance. Newey-West standard errors.

Panel III of Table 8 reports the estimation output of the following model, in which demographic variables are dropped out:

$$R_t^{BOND} = \alpha + \beta_1 \Delta sr_t + \beta_2 Spread_{t-1} + \beta_3 \pi_{t-1} + \beta_4 \Delta \pi_t + \beta_5 g_{t-1} + \beta_6 Gap_{t-1} + \varepsilon_t \quad (11b)$$

The results are poorer in terms of both estimation output and of diagnostic tests, thereby further supporting the relevance of the demographic dynamics.

To sum up, also the results for long-term government bonds are overall consistent across the different variants estimated, with the share of early working-aged being the only steadily significant variable among demographic ones. Consistently with the theoretical underpinnings, the negative sign of this variable suggests that a larger share of young people increases the demand for long-term government bonds, thereby increasing their prices and decreasing their returns. Furthermore, the non significant coefficients for late working-aged and retirees suggest that they may not particularly active on this market, which can be justified by the long investment horizon required by these kinds of assets.

7.3 Results for BOT

The model, which due to data availability is estimated over a different sample period (1981-2004), is:

$$R_t^{BOT} = \alpha + \beta_1 Pop_t^{20-39} + \beta_2 Pop_t^{40-64} + \beta_3 \Delta sr_t + \beta_4 \pi_{t-1} + \beta_5 \Delta \pi_t + \beta_6 g_t + \beta_7 Gap_t + \varepsilon_t \quad (10c)$$

Note that the term spread, previously included based on the expectation theory of the term structure, is here dropped.²⁶ Furthermore, GDP variables are no longer lagged; rather they are included at current values, in the light of the higher responsiveness of short interest rates to current economic conditions.

²⁶ When included, the estimated coefficient of the term spread always results not statistically significant.

Table 9: Results for Italian BOT, 1981 - 2004.

Variable	PANEL I Model (10c)		PANEL II Model (10c')		PANEL III Model (11c)	
	Coefficient	S.e.	Coefficient	S.e.	Coefficient	S.e.
α	-2.738***	0.537	-2.099***	0.467	-0.067***	0.017
Pop_t^{20-39}	2.323***	0.367	2.377***	0.290	-	-
Pop_t^{40-64}	5.822***	1.358	4.886***	1.109	-	-
Pop_t^{65+}	-	-	-1.351***	0.414	-	-
Δsr_t	0.002	0.002	0.004**	0.001	0.004	0.003
π_{t-1}	0.501**	0.189	0.340**	0.157	-0.497***	0.135
$\Delta\pi_t$	-0.201	0.263	-0.082	0.211	-0.527	0.456
g_{t-1}	12.493***	1.625	5.334*	2.540	7.415***	1.152
Gap_{t-1}	-0.542***	0.172	-0.365**	0.147	-0.742**	0.298
R^2	0.916		0.951		0.705	
Adjusted R^2	0.879		0.925		0.623	
DW	1.898		2.026		0.940	
Tests	Stat.	Prob.	Stat.	Prob.	Stat.	Prob.
F-statistic	24.976	0.000	36.392	0.000	8.607	0.000
Ljung-Box	6.378	0.783	14.384	0.156	9.2763	0.506
Homoskedasticity	0.509	0.876	1.811	0.217	1.894	0.140
Normality	0.674	0.714	0.688	0.709	1.560	0.458
Unit root	-4.819**	-	-5.694***	-	-4.767**	-
Wald	20.141	0.000	25.095	0.000	-	-
RESET (3)	2.150	0.143	1.826	0.196	0.930	0.450
Chow (1995)	0.841	0.615	0.253	0.969	2.730	0.084

Note: *, ** and *** denote 10%, 5% and 1% level of significance

Estimation output and diagnostic tests of model (10c) are reported in Panel I of Table 9. All the diagnostic tests are passed. On the whole, the estimated model fits quite well real data, especially if compared with what reported for stocks and long-term government bonds. In fact, in contrast with what observed for long-term government bonds and in line with evidence for stocks, both the demographic variables are statistically significant and, as expected, display positive signs.

When the share of the elderly is included in the specification, the model is:

$$R_t^{BOT} = \alpha + \beta_1 Pop_t^{20-39} + \beta_2 Pop_t^{40-64} + \beta_3 Pop_t^{65+} + \beta_4 \Delta sr_t + \beta_5 \pi_{t-1} + \beta_6 \Delta \pi_t + \beta_7 g_t + \beta_8 Gap_t + \varepsilon_t \quad (10c')$$

This specification not only passes all the diagnostic tests but also displays a higher fit to the real data (see Table 9, Panel II). In fact, all control variables but the inflation change rate are statistically significant and display signs which are consistent with those reported above for model (10c). Similarly, all demographic variables are strongly significant and signed consistently with expectations and with the results for (10c). Nevertheless, the inclusion of a non-stationary variable (the share of elderly) makes this model specification unbalanced therefore entailing a cautious interpretation of these results.

The relevance of the demographic variables is further tested by re-estimating the following model:

$$R_t^{BOT} = \alpha + \beta_1 \Delta sr_t + \beta_2 \pi_{t-1} + \beta_3 \Delta \pi_t + \beta_4 g_t + \beta_5 Gap_t + \varepsilon_t \quad (11c)$$

The exclusion of the demographic variables not only leads to overall poorer results in terms of diagnostic tests but also significantly reduces the degree of fit of the model to real data (see Table 9, Panel III).

In sum, also results for BOT are consistent across all estimated variants and point towards a significant effect of population age structure on asset returns.

Comparing the estimated coefficients for demographic variables across all the three asset return regressions, two observations naturally arise. First, coefficients estimated for the fixed income market are generally lower than those reported for the stock market. This might stem from the fact that Italian households are more active as investors on the stock rather than on fixed-income market.²⁷ Italian stock market thus appears more sensible to population age-structure changes than government bond ones.

²⁷ This conclusion is suggested by the Bank of Italy Financial Accounts (over the period 1995 – 2005) that provide data on the aggregate financial wealth of Italian households and explicitly take into account financial assets indirectly held via banks and other financial intermediaries. This evidence is somewhat in contrast to the Bank of Italy Survey on Household Income and Wealth, which however is significantly affected by non- or under-reporting problems (see Brunetti and Torricelli, 2007a).

Based on this, the most striking consequences of Italian population ageing are expected to be experienced by the stock market. Second, within each asset return regression, the highest coefficients among demographic variables are generally associated with the shares of working-aged, which are typically the most financially active share of the population. By contrast, elderly show the lowest (or even not statistically significant) coefficients: they thus appear to be less active with respect to the other shares of the population on the entire Italian financial market, which is reasonable given the generous pension system previously in force in Italy.

7.4 A comparative assessment with U.S.

The results for the extended specification are compared with Davis and Li (2003), who use a similar framework. Yet, as the authors do not extend their analyses also to short-term government bonds the comparison is possible only for stocks and long-term government bonds. Moreover, due to lack of sufficiently long time-series for dividend-yield, the estimation period for stock returns is different: 1950–1999 for Davis and Li (2003), 1973–2004 for this study.

Results for stock returns are reported in Table 10, whereby the model specification differs from Davis and Li (2003) only for the GDP-related variables here included lagged one period.²⁸ The better fit of Italian stock returns to lagged rather than current values of these variables may be interpreted as a sort of stickiness of stock market to real dynamics, which is reasonable in the light of the timing of data delivery. Since these variables are used as proxy for the expectations on future dividends growth and since data on the real economy are generally available with some delay (generally

²⁸ In this study the regressions are estimated without any dummy, while Davis and Li (2003) include dummies for years 1953 and 1957 in the model specification for stocks, and dummies for 1982, 1983, 1984 and 1985 in that for long-term government bonds in order to “*capture the high level of real rates in that period*”.

not before the following year) it is not surprising that the returns on stocks do not react to current values and react instead, quite soundly, to lagged values.

Table 10: Comparison with the US, returns on stocks.

Davis and Li 2003, US: 1950 - 1999			This Study, Italy: 1973 - 2004		
<i>Model</i>	<i>Coefficient</i>	<i>s.e.</i>	<i>Model</i>	<i>Coefficient</i>	<i>s.e.</i>
Constant	-2.97**	0.64	Constant	4.931*	2.532
Pop_t^{20-39}	-0.0024	0.0098	Pop_t^{20-39}	11.161*	5.711
Pop_t^{40-64}	0.108**	0.02	Pop_t^{40-64}	-22.489**	10.665
g_t	-3.4	6.5	g_{t-1}	-39.918***	6.652
Gap_t	-1.28	0.97	Gap_{t-1}	1.843	1.948
r_t	0.03**	0.009	r_t	-6.150***	1.402
Vol_t	-1.19*	0.62	Vol_t	-0.034	0.048
DY_{t-1}	0.092**	0.026	DY_{t-1}	0.007	0.012
R^2	0.54		R^2	0.435	
Adjusted R^2	0.45		Adjusted R^2	0.263	
RSS	0.58		RSS	0.951	
SE of regression	0.12		SE of regression	0.203	
Test	Statistic	Prob	Test	Statistic	Prob
F-statistic	6.0	0.0	F-statistic	2.533	0.044
LM (2)	1.1	0.36	LM (2)	1.081	0.357
White	0.53	0.47	White	1.398	0.258
Jarque-Bera	1.53	0.28	Jarque-Bera	1.469	0.480
ADF	-5.9	N/A	ADF	-5.223**	-
Wald on Pop_t^{40-64}	15.2	0.0	Wald on Pop_t^{40-64}	4.303	0.049
RESET	2.4	0.09	RESET	0.909	0.454
Chow	0.81	0.62	Chow	1.969	0.126

Note: *, ** and *** denote 10%, 5% and 1% level of significance. LM (2) is the Lagrange multiplier test for serial correlation up to second order. The Chow test is performed over the period 1990-99 for Davis and Li 2003) while over the period 1995-2004 in this study.

Both Davis and Li 2003 and our models pass all diagnostic tests and seem to fit quite well the data, with both demographic and most control variables being strongly significant. By contrast, in the Italian case the demographic variables display signs which are at variant with those in Davis and Li 2003 but consistent with theoretical expectations: a larger share of early middle-aged, typically more risk-loving, pushes upwards the demand for equities, thereby increasing their prices and hence their returns,

while the opposite holds for older working-aged people. In addition, the estimated coefficients for demographic variables are considerably higher than those reported for the US market. Hence, the population age-structure seems to play a role in determining stock returns which is more relevant in the Italian market than in the US one, whereby this difference may well stem from the more marked demographic transition occurring in Italy with respect to US.

Table 11: Comparison with the US, bond yields.

Davis and Li 2003, US: 1950 - 1999			This Study, Italy: 1958 - 2004		
<i>Model</i>	<i>Coefficient</i>	<i>s.e.</i>	<i>Model</i>	<i>Coefficient</i>	<i>s.e.</i>
Constant	12.3**	4.0	Constant	0.347	0.404
Pop_t^{20-39}	0.266**	0.052	Pop_t^{20-39}	-1.063**	0.480
Pop_t^{40-64}	-0.239**	0.084	Pop_t^{40-64}	0.230	0.864
Δsr_t	0.628**	0.1	Δsr_t	0.375**	0.185
$Spread_{t-1}$	-0.73**	0.125	$Spread_{t-1}$	-0.399**	0.166
π_{t-1}	-109.1**	9.7	π_{t-1}	-0.598***	0.176
$\Delta\pi_t$	-142.6**	10.0	$\Delta\pi_t$	-1.126***	0.162
g_t	-197.3**	58.9	g_{t-1}	-0.754	0.554
Gap_t	-5.8	6.4	Gap_{t-1}	0.003	0.034
R^2	0.98		R^2	0.808	
Adjusted R^2	0.97		Adjusted R^2	0.751	
RSS	4.9		RSS	0.009	
SE of regression	0.4		SE of regression	0.018	
Test	Statistic	Prob	Test	Statistic	Prob
F-statistic	102.9	0.0	F-statistic	14.216	0.000
LM (2)	16.2	0.0	LM (2)	11.017	0.000
White	1.8	0.19	White	2.498	0.030
Jarque-Bera	0.045	0.97	Jarque-Bera	1.322	0.516
ADF	0.06	N/A	ADF	-4.631*	-
Wald on Pop_t^{40-64}	1.98	0.81	Wald on Pop_t^{40-64}	1.231	0.275
RESET	0.74	0.14	RESET	1.769	0.173
Stability	-3.7	0.67	Stability	2.107	0.085

Note: see note under Table 10. Newey-West standard errors in the Italian case.

Table 11 compares the results obtained for long-term government bonds yields. On the whole, the results reported for the US and the Italian cases are analogous in

terms of both diagnostic tests and model fit to the data. Yet, some differences arise with respect to the demographic variables coefficients. While Davis and Li 2003 find that both early and late working-aged are statistically significant, in Italy only the younger share of the population actually affects the dynamics of the long-term government bond yields. Furthermore, as in the case of stocks, coefficient signs contrast with Davis and Li 2003 but are in line with expectations: as the theory suggests in fact a higher share of young increases the demand for long-term bonds, thereby exerting an upward pressure on their prices and a negative one on their returns.

8. Conclusions

The basic idea of this paper is that demographic variables may play a role in explaining financial asset returns only in the presence of a strong demographic dynamics, such as the steep population ageing that Italy has been experiencing since the seventies. In order to investigate the relationship between asset prices and demographic dynamics we have first set up a stylized OLG model formalizing that the capital price is determined by the unbalances between its demand and supply, which are in turn affected by the dynamics of demographic changes. This contrasts with the models in Abel 2001 and Poterba 2001 where the level (rather than the dynamics) of a demographic factor plays a role in determining the capital price behaviour. In order to test the implication of the model, we take Italy as a case study since it is experiencing one of the steepest ageing dynamics in the world and compare the results with the evidence on the US. In the purely demographic specification, the results show that demographic variables alone cannot satisfactorily explain the dynamics of financial returns over the period considered. By contrast, when the regression specification is extended to include also a set of explanatory control variables a different picture emerges. The results are largely

consistent across variants, the signs observed for the demographic variables are consistent with the theory and the overall evidence supports a significant role of demographic variables in affecting financial returns. This is particularly true in the stock market, where the estimated coefficients are generally more significant and greater than in the fixed-income market. Furthermore, compared with the literature for US, the estimates of demographic variables are in most cases higher in magnitude. This result is consistent with the implications of the OLG model proposed in this paper, whereby the sensitiveness of asset prices to demographic factors may differ across countries due to the specific ageing dynamics.

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