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Asset Meltdown – Fact or Fiction?

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Abstract

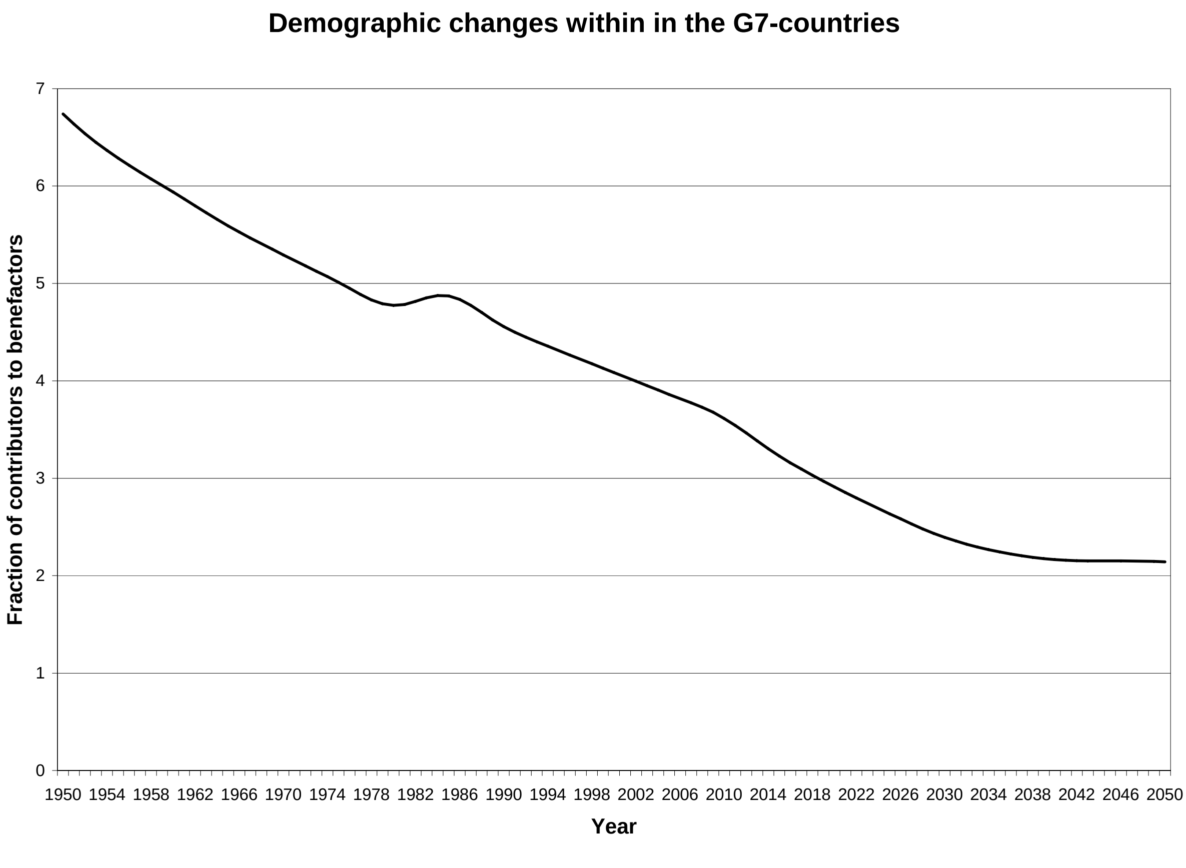
This paper analyzes the relation between demographic structure and real asset returns on treasury bills, bonds and stocks for the G7-countries (United States, Canada, Japan, Italy, France, the United Kingdom and Germany). A macroeconomic multifactor model is used to examine a variety of different demographic factors from 1951 to 2002. There was no robust relationship found between shocks in demographic variables and asset returns in the framework of these models, which suggests that Asset Meltdown is rather fiction than fact.

JEL Classification: G12 (Asset Pricing), G15 (International Financial Markets), J14 (Economics of the Elderly)

I Introduction

In recent decades, there were two simultaneous effects in most of the industrialized countries. Declining birth rates on the one hand were accompanied by increasing life expectancies on the other hand. Due to these trends, traditional pay-as-you-go pension systems face increasing problems, since the benefits of the retirees are primarily funded by contributions from the labour force. Without tremendous changes, the contributors-beneficiaries ratio will decrease, leading to a cash shortage in these types of pension systems. Figure 1 shows the development of this ratio from 1950 to 2050 within the G7-countries. It has been assumed that individuals aged 20 to 64 were contributors; the ones aged at least 65 beneficiaries. The contributors-beneficiaries ratio declined from 6.7 : 1 in 1950 to 3.9 : 1 in 2004. According to projections, a further decline to 2.1 : 1 in 2050 is expected.

Figure 1: Demographic changes within the G7-countries



The figure depicts the development of the ratio between the potential contributors and benefactors of a pensions system in the G7-countries in total. The potential contributors are those aged 20 to 64. The potential benefactors are defined accordingly as the population aged 65 and older. Calculations are based on data of the United Nations Population Database.

Funded pension systems, in which individuals save during their working life to build up a capital stock that suffices to finance their expenses as retirees seem to be a reasonable alternative to unfunded ones. Hence, current reforms have put a stronger emphasis on funded pension systems. Nevertheless, it is argued that these systems can also be influenced by demographic changes. Large generations retiring at once might want to withdraw substantial amounts from capital markets, which could result in a significant decline of asset prices, a phenomenon referred to as Asset Meltdown. If such relationship between demographic structure and asset returns exists, it is questionable whether funded pension systems could help solve the problem of financing pension systems for aging populations.

Contradicting the Asset Meltdown hypothesis is an "Asset Meltup" hypothesis. If a nation is aging, the working population is decreasing. The decrease in work force might lead to a situation where labor becomes the limited production factor. This in turn would imply that the price for labor would increase relative to the price of capital. Consequently, the demand for capital could well be increasing, which would result in an "Asset Meltup."

The arguments founding the Asset Meltdown phenomenon only hold ceteris paribus, if at all. Asset prices in international capital markets do not only depend on national demographical changes. As empirical research based on Arbitrage Pricing Theory (APT) has shown, a substantial part of asset returns is driven by macroeconomic factors. Following this logic, our paper empirically analyzes the impacts that changes in demographic structure have on asset prices in a multifactor model. The outline of the paper is as follows: section II reviews the relevant literature. Section III provides the description of demographic as well as macroeconomic factors, and section IV describes the specification of the model. Section V introduces the data, section VI describes the tests of assumptions. Section VII documents our empirical results. Section VIII contains a brief summary.

II Literature Review

The Asset Meltdown phenomenon has been addressed in the literature from both an empirical and a theoretical perspective. Our review of the literature follows this classification. In an early empirical examination, the impact of demographic structure on asset returns is discussed by *Mankiw/Weil* (1989), who analyzes the impact of demographic changes on real estate prices in the US and predicted a sharp decline in prices due to the changing demands of the baby boomers. A similar Canadian study by *Engelhardt/Poterba* (1991) does not find any significant correlation. *Börsch-Supan* (1993) predict no substantial changes in German real estate prices until 2020 and predict slightly decreasing prices thereafter due to changing demand by an aging population. A rise in the average age in the US is found by *Bakshi et al.*

(1994) to correspond to a rise in the risk premium of a S&P500-portfolio. *Claude et al.* (1997) find a relationship between the average age of the population in the US and long-horizon returns of the S&P 500. On the contrary, *Poterba* (2001, 2004) does not find any systematic relationship between demographic structure and returns on stocks, bonds and treasury bills. He analyzes data for the United States, Canada and the United Kingdom and finds empirical evidence that coefficients differ significantly across the countries and asset classes. For the United States he notices a negative relationship between the percentage of the population aged 40 to 64 and bond returns, whereas for Canada he discovers a positive relationship. Both of these findings are significant. *Ang/Maddaloni* (2003) analyze the relation between logarithmic demographic changes and risk premiums on equity for 20 different countries including the United States, Japan, the United Kingdom and Germany. Similar to *Poterba* (2001), they find some significant relationships between demographic structure and asset returns. Nevertheless, the order of magnitude of these relationships differs substantially between countries.

In the context of a macroeconomic multifactor model, *Davis/Li* (2003) examine the impact of demographic changes on the returns of stocks and bonds. *Jamal et al*. (2004) also analyze the impact of demographic structure on stock prices in the United States and the United Kingdom and show that the proportion of the population in the prime earning age has had a direct influence on stock prices. A Lucas asset-pricing model is used by *Martin* (2005) to show empirically that the primary force underlying the evolution of real house prices was the systematic and predictable change in the working age population driven by the baby boom.

Yoo (1994b) and *Goyal* (2004) do not address the Asset Meltdown phenomenon directly, but instead examine the impact of demographic factors on asset holding and capital flows. *Yoo* (1994b) analyzes asset holdings and finds that demographic factors other than age, such as sex and ethnicity, have substantial influence on asset holdings of US-Americans. *Goyal* (2004) considers both out- and inflows of free capital to the US stock market and finds outflows to be positively correlated with the number of persons aged 65 and over, but negatively correlated with the number of those aged 45 to 64. A plausible interpretation might be that those aged 45 to 64 are in their prime earning years and are saving substantial amounts of their income for retirement, which they want to invest (at least partly) into the stock market. At about the age of 65 when they retire, they begin withdrawing these assets as retirement income.

The economic impacts of an aging society are also addressed by various authors from a theoretical perspective. *Yoo* (1994) predicts that the baby boom would cause a temporary decline in the capital-labour ratio. Employing an overlapping generation model, *Brooks* (2000) forecasts baby boomers to have substantially lower returns than earlier generations even when markets are rational and forward looking. *Ameriks/Zeldes* (2001) describe equity-ownership in the United States and show that it has a hump-shape pattern when correlated with age. When separated based on ownership, the pattern is nearly constant. According to *Abel* (2001), a baby boom causes an increase in stock prices. Furthermore, he predicts that stock prices will fall when the baby boomers retire. In his model, these effects occur despite consumer anticipation. In a further paper, *Abel* (2003) develops a model to predict the effects of baby boomers on the price of capital and concludes that when baby boomers are in their prime earning years, they increase national saving and therefore decrease the price of capital.
The influence of demographic changes on international capital flows is addressed by *Börsch-Supan et al.* (2003), who conclude that countries with quickly aging populations stand to face substantial capital outflows. *Geanakoplos et al.* (2004) construct an overlapping generation model to show that demographic shocks can generate substantial swings in asset values. According to their model, current movements in stock markets are two to three times greater than demographic changes can explain.

In an earlier paper, *Poterba* (2001, p. 583) gives three principal suggestions for further empirical research:

- **Internationally integrated capital markets:** "Any attempt to assess the future link between asset returns and demographic structure must also consider the potentially important role of integrated world capital markets."
- **Reaction to shocks:** "A second issue […] concerns the timing of any asset market reaction to demographic shocks." The 'news' about demography is revealed when cohorts are born, not when they reach their prime saving years".
- **Control for nondemographic factors:** "Finally, the current analysis has ignored a wide range of nondemographic factors that may affect equilibrium real returns and asset prices."

These suggestions are addressed in the following empirical examination.

III Demographic and Macroeconomic Factors

According to economic theory, individuals wish to smooth consumption over their lifetime (*Modigliani/Brumberg* (1954), *Friedman* (1957), *Ando/Modigliani* (1963)). Due to this so-called life-cycle hypothesis, savings differ with income. As income tends to increase with age until retirement, savings should be low for younger individuals and higher for middle-aged people. Because income is in most cases substantially lower after retirement, retirees' savings should be negative. Positive savings tend to increase the demand for assets, while dissavings tend to increase the supply of assets.

Poterba (2001) analyzes the demographic variables „Median Age," „Average Age of those aged 20+," „percentage of population aged 40 to 64," „Fraction of Population aged 40 to 64 to population aged 65+" and „Fraction of Population aged 40 to 64 to Population aged 20+" as potential indicators for an asset meltdown. The bivariate regression

$$R_{i,t} = c + \beta_j Z_{j,t} + \varepsilon_{i,t} \tag{1}$$

where $R_{i,t}$ denotes the real return of asset i in year t was run for each of these demographic variables $Z_{j,t}$.

In similar approaches, *Poterba* (2004), *Goyal* (2004) and *Ang/Maddaloni* (2005) use the percentage of individuals aged from 40 to 64 as a measure for middle-aged individuals and those aged over 65 as a measure for retirees. One can argue that it is not the changes in these variables, but the **relation** of potential savers to potential dissavers, which drives asset prices. Therefore *Poterba* (2001, 2004) uses such factors as the percentage of the middle-aged of a population and the ratio of the middle-aged to those of the retirees as explanatory variables in bivariate regression models with the asset returns as an independent variable.
The demographic factors are defined as follows:

$$p_{c,t}^{young} := \frac{|\text{population aged 20 to less than 40 in year } t \text{ and country } c|}{|\text{population aged 65 and older in year } t \text{ and country } c|}$$

$$p_{c,t}^{middle} := \frac{|\text{population aged 40 to less than 65 in year } t \text{ and country } c|}{|\text{population aged 65 and older in year } t \text{ and country } c|} \tag{2}$$

Demographic variables as well as their growth rates are usually highly autocorrelated, and thus far from being unpredictable. In efficient capital markets, changes in prices should only be driven by new information (**shocks**). Therefore forecasts for the demographic variables were computed using an AR(p)-model, whose coefficients have been estimated in rolling regressions based on all observations that were available up to that point in time. For each estimation the lag $p < 3$ was chosen according to the Schwarz criterion. As a maximum lag of $p = 3$ did not improve the forecasts significantly, the maximum lag was not extended to avoid loosing too many observations. Another reason for not choosing a higher maximum lag was the problem of numerical instability. An ARMA(p) was also tested, but due to the limited number of observations, its results depended heavily on the initialisation of the shocks, which resulted in a strong effect on the results. The idea of calculating shocks using an ARMA(p)-model was therefore rejected. For estimating the shocks using a VAR, the number of observations was too limited.

In order to address the issue of integrated international capital markets, the demographic factors were not only calculated for the countries under consideration but also for all G7-countries as a whole, which makes it possible to include a potential impact of **international demographics** on asset prices in the respective national markets.

When analyzing unexpected changes in cohorts' magnitudes, one notes that they are mainly driven by (unexpected) shifts in mortality probabilities and fertility rates. Changes in mortality rates for the cohorts in concern are highly correlated. Thus, shifts in life expectancy can be regarded as a condensed measure for all changes in mortality probabilities. Taking all the above said into consideration, models including shocks in **life expectancy** of a new born and **fertility rates** as demographic factors were computed.

With exception to studies such as *Davis/Lee* (2003) and *Poterba* (2004), most of the models only include demographic factors as explanatory variables, thus ignoring other factors that may affect equilibrium asset prices. It is quite likely that the models are underfitted, implying that the coefficients in the regressions might be biased. Empirical research based on Arbitrage Pricing Theory (APT) starting with *Chen/Roll/Ross* (1986) has shown that a large part of asset returns is driven by **macroeconomic factors**. In addition to demographic factors, unexpected changes in the growth rates of GDP, exports, exchange rate to USD, oil price, inflation, long-term yield and the spread between long and short term rate were also controlled for. In our sample, changes in growth rates of oil price as well as exchange rates can be considered as unexpected. Shocks for the other macroeconomic variables are calculated using the same estimation procedure as described above for demographic variables.

IV Regression models

Poterba (2001) and *Ang/Maddaloni* (2005) use demographic factors only in bivariate models, while *Poterba* (2004) and *Goyal* (2004) allow for more than one demographic variable in their estimation. To avoid omitted variables, the latter approach was employed. As the returns on treasury bonds and the growth rate of housing prices are autocorrelated, an AR(1)-term is included in the regressions.

Let $r_{i,c,t}$ denote the return on asset i, $\tilde{p}_{c,t}^{young}$ ($\tilde{p}_{c,t}^{middle}$) denote the shock in $p_{c,t}^{young}$ ($p_{c,t}^{middle}$) and $\tilde{m}_{j,c,t}$ denote the shock in the growth rate of the macroeconomic variable j, both at time t and in country c. The first set of regressions is then defined as

$$r_{i,c,t} = \alpha_{i,c} + \beta_{1,i,c} \cdot \tilde{p}_{c,t}^{young} + \beta_{2,i,c} \cdot \tilde{p}_{c,t}^{middle} + \beta_{3\,i,c} \cdot r_{i,c,t-1} + \sum_{j=1}^{n} \beta_{j+3,i,c} \cdot \tilde{m}_{j,c,t} + \varepsilon_{i,c,t}. \qquad (3)$$

For an international approach, $p_{G7,t}^{young}$ and $p_{G7,t}^{middle}$ were computed from the sums of the corresponding national demographic data of all G7-countries. The second model is then

$$r_{i,c,t} = \alpha_{i,c} + \beta_{1,i,c} \cdot \tilde{p}_{G7,t}^{young} + \beta_{2,i,c} \cdot \tilde{p}_{G7,t}^{middle} + \beta_{3\,i,c} \cdot r_{i,c,t-1} + \sum_{j=1}^{n} \beta_{j+3,i,c} \cdot \tilde{m}_{j,c,t} + \varepsilon_{i,c,t}. \qquad (4)$$

Let $le_{c,t}$ denote the life expectancy and $fr_{c,t}$ the fertility rate, both at time t in country c. The third set of regressions is then defined as

$$r_{i,c,t} = \alpha_{i,c} + \beta_{1,i,c}\, \tilde{le}_{c,t} + \beta_{2,i,c} \cdot \tilde{fr}_{c,t} + \beta_{3\,i,c} \cdot r_{i,c,t-1} + \sum_{j=1}^{n} \beta_{j+3,i,c} \cdot m_{j,c,t} + \varepsilon_{i,c,t}. \qquad (5)$$

In an attempt to use the cross section dimension, the parameters for (2), (3) and (4) were also estimated using a panel approach with $\alpha_{i,c} = \alpha_i$ and $\beta_{j,i,c} = \beta_{j,i}$ for all c.

V Data

Demographic data was obtained from the United Nations Population Database.

The data on stocks, bonds, treasury bills and inflation was obtained from the Dimson-Marsh-Staunton (DMS) Data Base with the exemption of data on inflation for Germany, which was calculated for 1950 to the end of this series in 1999 from the consumer price index for an average household of four people. From 2000 to present inflation was calculated from the new harmonized consumer price index. Both series were obtained from the German federal office of statistics.

Unlike the data for conventional assets, real estate data for is only available for parts of the sample. For each country, the reliable representative index with the longest history was chosen. Furthermore, the construction of the price indices and the observed market is different in all countries. This is due in part to national differences in housing standards (for example, wooden houses are typical for Japan, where in most locations buildings must be adapted to potential earthquakes). Thus, the real estate indices must be regarded as proxies for prices of typical housings in the corresponding countries.

For Canada, the New House Price Index[1] published by the Bank of Canada, which only ranges back to 1982, was used. Real estate prices for Germany were taken from German Federal Statistical Office for 1958 to 1974 using the Price Index for New Buildings (including VAT) for Conventional Constructions, and from Bulwien Gesa for the years 1975 to 2002.[2] French real estate prices were obtained from the Chambre Interdépartmentale des Notaires de Paris from 1950 to 1999 (Indices du Prix des Logements) and the National Institute for Statistics and Economic Studies (Index National du Prix du Bâtiment) from 1974 to 2002[3]. Italian real estate prices were obtained from Nomisma (Price Index for New and Fully Renewed Apartments) from 1966 to 2002. Real estate prices were also obtained from the Japan Real Estate Institute (National Wooden House Market Value Index) from 1957 to 2002, UK's Office of the Deputy Prime Minister (weighted average of prices for a standard mix of

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[1] , 75% Detached Bungalow, 25% Executive Detached Two-Storey

[2] To estimate observations for 1958 to 1974, we used a simple imputation model based on the regression of the price index from the German Federal Statistical Office and the interest spread on the Bulwien real estate prices (adj. $R^2 = 0.829$).

[3] See *Friggit* (2001) for more information about the construction of the indices.

dwellings) from 1951-2002, and Freddie Mac (US House Price Index, based on single unit residential houses only) from 1971-2002.[4]

Data on GDP, exports, the oil price, and exchange rates against the dollar were obtained from the IMF database. The long-term yield was defined as the yield of a government bond, and the spread as the difference between the coupon yield of a government bond and the return of a treasury bill. Data on long-term government bond-yields was obtained from the IMF. Missing values were filled with data from *Shomera* (1991) as follows: Germany from 1950 to 1953: German long-term government bond yields for 1954 and 1955 were linearly interpolated from the 1953 and 1956 values; Japan from 1950 to 1963: Japanese 1964 and 1965 long-term government bond yields were generated from the 1963 and 1966 values accordingly; US from 1950 to 1953.

To deal with the problem of missing data in some time series, the missing values were estimated by linear interpolation from time series with a correlation of at least 0.95 with the former series for the overlapping period. In particular we estimated German GDP before 1960 from absolute values of German GDP (correlation in the overlapping period: cop. = 0.962), Italian GDP before 1960 from the industrial production (cop. = 0.993), Japanese GDP before 1955 from the industrial production (cop. = 0.996), German exports before 1960 from German volume of exports (cop. = 0.992), and French real estate prices from 2000 to 2002 from Index national du prix du bâtiment (cop. = 0.979).

VI Tests of Assumptions

To rule out the opportunity of spurious regressions, the time series was first tested for **stationarity** using various tests. As such tests are known to sometimes lead to different results, several of them were applied to obtain valid conclusions. For the analysis of the time series, the Augmented Dickey-Fuller test maximizing the Schwarz Info Criterion with a maximum lag of 10, the Phillips-Perron-Test, both with sample-size-adjusted values due to *MacKinnon* (1996), and the NG-Perron test-statistics and the ERS test-statistics were applied. Further the null-hypothesis of stationarity due to *Kwiatkowski et al.* (1992), hereafter referred to as KPSS, was tested. The KPSS-test is an asymptotic one; its finite distribution depends on the number of observations and the lag chosen to estimate the long-run variance. The Bartlett-Kernel and the *Newey-West* (1987) bandwidth were chosen. The finite sample distribution for

[4] We thank *J. Friggit* for data of French housing prices.

the trend-stationary case does not differ significantly from the asymptotic KPSS-distribution according to *Hornok/Larsson* (2000). Therefore, the critical values given in *Kwiatkowski et al.* (1992) were applied to test for the null-hypothesis of stationarity.[5] As the null of non-stationarity could not be rejected in several cases, the regressions' residuals were also controlled for stationarity. Residual based test were applied with adjusted values according to *Phillips/Ouliaris* (1990). To avoid the spurious regression problem, the determining variables were tested for **multicollinearity** in two steps. First, the bivariate correlations were calculated. If a correlation was not less than 0.8, one of the factors was omitted from the regression model. If possible, demographic variables were not eliminated. Second, the remaining factors were tested for multivariate correlation. Again, to avoid eliminating demographic variables, macroeconomic variable and AR-term were tested first and omitted in case of a variance inflation factor VIF ≥ 10.

VII Results

The results for the **regression model with domestic demographic data** (eq. 2) in table 1 only provide significant estimators for 11 out of 58 coefficients, either at the 1%-, 5%- or 10%-level. According to the life-cycle hypothesis, middle-aged people save for retirement in significant amounts, and retirees dissave. In line with this theory, the regression coefficients with respect to the explanatory variable $\tilde{p}_{c,t}^{middle}$ should be positive. $\tilde{p}_{c,t}^{young}$ should be positive as well, but lower than $\tilde{p}_{c,t}^{middle}$, as young people usually tend to save less. However, of the significant results, only three coefficients show the expected sign while eight do not.

For the **stock markets,** significant results can only be obtained for Canada, where the coefficient for the first ratio does not have the expected sign while the second ratio is positive. The models capture the variation of the stock markets in very different amounts: while the adjusted R^2 for Japan is only 0.073, the return of UK stocks is explained with an adjusted R^2 of 0.311. Nevertheless, neither the regression coefficients for $\tilde{p}_{c,t}^{young}$ nor for $\tilde{p}_{c,t}^{middle}$ are significant for UK stocks. For **bonds**, 5 out of 15 are significant, but all 5 are negative. Even though adjusted R^2s for **treasuries** are at least 0.841 (Germany), demographics came up to be significant only for two coefficients. For **housing**, the results do not show a clear pattern;

[5] The critical values for the level-stationary case, trend for 50 observations and lag 3 are 0.120, 0.141 and 0.182 at the 10%, 5% and 1%-level respectively. The critical values for 50 observations and lag 10 are 0.136, 0.145 and 0.160 at the 10%, 5% and 1%-level, respectively. These values differ significantly from the asymptotic values reported in *Kwiatkowski et al.* (1992), which are 0.119, 0.146 and 0.216, respectively.

while the results indicate an Asset Meltdown for Italy, housing in the US tends to decrease in value with a growing $\tilde{p}_{c,t}^{middle}$. Coefficients for $\tilde{p}_{c,t}^{young}$ could not be estimated in Canada and Italy as the lagged growth rate of housing prices as an AR-term inducted additional multicollinearity. The remaining results do not show a clear picture.

Table 1: Regression Model with domestic demographic variables

asset	country	R^2	adj. R^2	β for $\tilde{p}_{c,t}^{young}$			β for $\tilde{p}_{c,t}^{middle}$		
Stocks	CAN	0.357	0.168	-3.467	**	(-2.361)	13.600	***	(3.585)
	D	0.415	0.242	2.341		(1.428)	0.371		(0.110)
	F	0.362	0.198	NA			2.751		(0.661)
	I	0.407	0.233	0.094		(0.047)	1.789		(0.557)
	J	0.284	0.073	6.383		(1.074)	5.076		(0.892)
	UK	0.467	0.311	-2.216		(-0.809)	4.565		(1.145)
	USA	0.281	0.096	-2.565		(-0.655)	7.450		(1.267)
	Panel	0.174	0.147	-0.147		(-0.168)	2.165		(1.516)
Bonds	CAN	0.705	0.619	-0.036		(-0.056)	-1.348		(-0.593)
	D	0.639	0.533	-0.045		(-0.133)	-1.189	***	(-2.827)
	F	0.435	0.289	NA			0.657		(0.398)
	I	0.506	0.360	-0.353		(-0.801)	0.883		(1.069)
	J	0.548	0.415	-7.883	***	(-3.790)	-0.726		(-0.383)
	UK	0.669	0.572	-1.497		(-0.865)	1.060		(1.045)
	USA	0.785	0.730	-8.904	***	(-4.741)	-6.467	***	(-3.486)
	Panel	0.382	0.362	-0.673	*	(-1.878)	0.294		(0.562)
Treas.	CAN	0.964	0.953	-0.060		(-1.304)	-0.525	***	(-3.003)
	D	0.877	0.841	-0.046		(-0.462)	0.009		(0.063)
	F	0.923	0.903	NA			0.121		(0.388)
	I	0.934	0.914	0.253	**	(2.438)	-0.216		(-1.520)
	J	0.934	0.914	0.291		(0.841)	-0.239		(-1.620)
	UK	0.929	0.908	0.397		(1.656)	0.090		(0.427)
	USA	0.917	0.895	-0.234		(-0.964)	0.155		(0.325)
	Panel	0.887	0.884	0.053		(0.817)	0.101		(1.219)
Housing	CAN	0.751	0.527	NA			-0.457		(-0.143)
	D	0.604	0.480	-0.164		(-0.805)	0.063		(0.201)
	F	0.756	0.694	NA			-0.689		(-1.321)
	I	0.636	0.510	NA			2.259	**	(2.152)
	J	0.635	0.527	0.833		(1.306)	0.962		(1.275)
	UK	0.559	0.429	-1.145		(-1.074)	1.579		(1.063)
	USA	0.505	0.293	2.145		(0.863)	-7.584	***	(-2.899)
	Panel	0.244	0.214	-0.260		(-0.743)	0.341		(0.881)

The coefficients are the results of the regression of four assets in national markets on the shocks in the ratio of the domestic population of young people (aged 20-39) to that of retirees (aged 65+) $\tilde{p}_{c,t}^{young}$. The nominator of $\tilde{p}_{c,t}^{middle}$ is the population of middle aged people (aged 40-64). The coefficients of various control variables can be found in the appendix. Coefficients that are significant at the 1%- level (5%, 10%) are marked with *** (**, *). *T*-values are given in parentheses. NA denotes that the coefficient could not be estimated due to multicollinearity.

The model with **international demographic variables** does not provide better support for the existence of an Asset Meltdown. Here, 17 out of 62 coefficients for the demographic variables are significantly different from zero. Nine are positive and thus support the Asset Meltdown hypothesis, while eight are not. Again, the models for the stock markets in general show lower R^2s than those for bonds, treasuries and housing. The (adjusted) R^2s of the national and international models differ only slightly, if at all.

For the Canadian **stock market,** the coefficient for unexpected changes in the middle-aged population remains at the same level as in the domestic model. The coefficients for $\tilde{p}_{G7,t}^{young}$ are significant and negative for German stocks and the stock panel data set. Japanese **bonds** now show a significant and positive coefficient for $\tilde{p}_{G7,t}^{young}$, whereas they were significantly negative in the domestic model. At best, the results for **treasuries** with 4 positive and significant estimations provide limited support for the Asset Meltdown phenomenon. For **housing**, the coefficient for Italy is positive and significant, like in the domestic model, but indicates a increase in house prices of about 1,200% when an unexpected change of 1 in the ratio $\tilde{p}_{G7,t}^{middle}$ occurs.

Table 2: Regression Model with international demographic variables

asset	Country	R^2	adj. R^2	β for $\tilde{p}^{young}_{G7,t}$			β for $\tilde{p}^{middle}_{G7,t}$		
Stocks	CAN	0.254	0.035	-3.430		(-1.335)	13.996	**	(2.212)
	D	0.455	0.295	-11.939	**	(-2.522)	11.769		(1.490)
	F	0.366	0.179	-2.450		(-0.538)	6.758		(0.755)
	I	0.427	0.259	-2.366		(-0.497)	12.469		(1.084)
	J	0.291	0.083	-5.610		(-0.875)	-3.176		(-0.336)
	UK	0.476	0.322	-5.864		(-1.658)	7.148		(1.215)
	USA	0.271	0.083	-2.352		(-1.072)	6.896		(1.318)
	Panel	0.181	0.154	-3.725	**	(-2.381)	5.638	*	(1.958)
Bonds	CAN	0.711	0.626	-0.563		(-0.362)	-2.039		(-0.563)
	D	0.695	0.605	-2.394	*	(-1.965)	-0.342		(-0.264)
	F	0.552	0.421	-4.268	***	(-4.021)	6.639	*	(1.952)
	I	0.497	0.349	-0.161		(-0.144)	0.971		(0.299)
	J	0.519	0.378	5.021	**	(2.520)	-10.685	***	(-4.040)
	UK	0.665	0.567	-0.970		(-0.831)	-0.184		(-0.059)
	USA	0.717	0.644	-2.743	**	(-2.280)	-6.005	**	(-2.427)
	Panel	0.387	0.367	-0.592		(-0.871)	-1.596		(-0.956)
Treas.	CAN	0.951	0.937	0.011		(0.066)	-0.388		(-1.115)
	D	0.880	0.844	0.107		(0.433)	-0.357		(-1.228)
	F	0.941	0.924	-0.919	***	(-3.864)	0.921	**	(2.071)
	I	0.933	0.914	0.484	**	(2.202)	-0.720		(-1.286)
	J	0.934	0.915	0.449	*	(1.705)	-0.380		(-0.946)
	UK	0.932	0.912	0.536	*	(1.938)	-0.294		(-0.958)
	USA	0.913	0.891	-0.006		(-0.028)	-0.093		(-0.219)
	Panel	0.886	0.883	0.121		(1.063)	-0.113		(-0.589)
Housing	CAN	0.763	0.550	NA			-1.313		(-0.963)
	D	0.633	0.518	1.059		(1.598)	-1.678		(-1.616)
	F	0.751	0.678	-0.436		(-0.404)	0.013		(0.009)
	I	0.689	0.565	-3.168		(-0.911)	12.191	**	(2.150)
	J	0.642	0.537	0.716		(1.219)	0.724		(1.158)
	UK	0.538	0.402	0.847		(0.610)	-0.958		(-0.412)
	USA	0.369	0.140	NA			-0.212		(-0.123)
	Panel	0.243	0.213	0.231		(0.320)	-0.230		(-0.176)

The coefficients are the results of the regression of four assets in national markets on the shocks in the ratio of the population of young people (aged 20-39) to that of retirees (aged 65+) in the G7, $\tilde{p}^{young}_{G7,t}$. The nominator of $\tilde{p}^{middle}_{G7,t}$ is the population of middle aged people (aged 40-64). The coefficients of various control variables can be found in the appendix. Coefficients that are significant at the 1%- level (5%, 10%) are marked with *** (**, *). *T*-values are given in parentheses. NA denotes that the coefficient could not be estimated due to multicollinearity.

Table 3 contains the result for the models with life expectancy and fertility rate as demographic variables. Here, 15 out of 64 estimations are significant. If the hypothesis of an Asset Meltdown holds, the coefficients for shocks in life expectancy should be negative, and positive for shocks in fertility rate. However, 6 out of 8 significant coefficients for $\tilde{le}_{c,t}$ are positive, and for $\tilde{fr}_{c,t}$ 4 out of 7 are negative, contradicting the hypothesis of an Asset Meltdown. The (adjusted) R^2s are of about the same order of magnitude as the corresponding values in the two preceding tables.

For **stocks**, only one significant coefficient can be observed. The estimator for β of $\tilde{fr}_{c,t}$ indicates that the return on Canadian stocks increases by 33,700% if $\tilde{fr}_{c,t}$ increases by 1. The results for **bonds** and **treasuries** also do not support the hypothesis of an Asset Meltdown. For housing, only two significant coefficient estimators can be observed, of which only one has the expected sign.

Table 3: Regression Model with Life Expectancy and Fertility Rate

asset	country	R^2	adj. R^2	β for $\tilde{le}_{c,t}$			β for $\tilde{fr}_{c,t}$		
Stocks	CAN	0.277	0.064	-16.070		(-1.640)	337.596	*	(2.023)
	D	0.405	0.230	-3.400		(-0.213)	141.861		(0.689)
	F	0.358	0.169	9.907		(0.640)	52.452		(0.299)
	I	0.437	0.272	41.684		(1.082)	8.667		(0.031)
	J	0.272	0.058	-16.122		(-0.895)	13.741		(0.062)
	UK	0.470	0.315	13.732		(1.036)	105.250		(0.561)
	USA	0.257	0.065	2.078		(0.201)	-46.381		(-0.531)
	Panel	0.169	0.141	2.145		(0.559)	27.716		(0.559)
Bonds	CAN	0.735	0.657	-2.579		(-0.742)	-99.505	*	(-1.849)
	D	0.619	0.507	3.004		(1.548)	-24.546		(-0.895)
	F	0.499	0.351	4.037		(0.742)	-81.616		(-1.279)
	I	0.507	0.361	-5.321		(-0.432)	-49.165		(-0.865)
	J	0.484	0.332	12.025		(1.374)	190.796	**	(2.192)
	UK	0.691	0.600	4.463	*	(1.870)	-157.035	*	(-1.927)
	USA	0.637	0.543	-9.904		(-1.445)	18.726		(0.386)
	Panel	0.382	0.362	-1.733		(-0.785)	-30.294		(-1.231)
Treas.	CAN	0.955	0.942	0.859	**	(2.660)	-15.912	**	(-2.225)
	D	0.890	0.857	1.178	**	(2.037)	-8.342		(-0.948)
	F	0.947	0.931	3.556	***	(3.560)	27.192	***	(3.859)
	I	0.932	0.912	-2.373	**	(-2.050)	0.018		(0.002)
	J	0.932	0.912	-0.707		(-0.724)	7.213		(0.506)
	UK	0.923	0.900	-0.011		(-0.010)	-4.057		(-0.268)
	USA	0.928	0.910	1.249	**	(2.319)	2.563		(0.651)
	Panel	0.889	0.886	0.580	*	(1.705)	6.149		(1.599)
Housing	CAN	0.773	0.521	-5.770		(-0.772)	-36.278		(-0.625)
	D	0.600	0.475	-0.625		(-0.309)	7.264		(0.319)
	F	0.753	0.680	0.249		(0.060)	19.806		(0.686)
	I	0.694	0.571	1.096		(0.158)	-206.629	***	(-3.093)
	J	0.612	0.498	-0.434		(-0.156)	2.716		(0.091)
	UK	0.535	0.398	1.113		(0.395)	-20.809		(-0.414)
	USA	0.423	0.176	-6.365		(-0.901)	-83.877		(-1.084)
	Panel	0.264	0.236	-3.844	**	(-2.174)	-29.990		(-1.635)

The coefficients are the results of the regression of four assets in national markets on shocks in life expectancy $\tilde{le}_{c,t}$ and fertility rate $\tilde{fr}_{c,t}$. The coefficients of various control variables can be found in the appendix. Coefficients that are significant at the 1%- level (5%, 10%) are marked with *** (**, *). *T*-values are given in parentheses. NA denotes that the coefficient could not be estimated due to multicollinearity.

As the findings do not show a clear pattern, several variations of the regression models have been estimated, where the **percentages of the population** aged 20 to 39, 40 to 64, and 65 and older were also used. Furthermore, to address the question of whether a potentially different dissaving behaviour of retirees at different age has an impact on asset prices, the group of retirees was split into those younger than 80 and those 80 and above. The percentages were then calculated accordingly; for the ratios, the population of those aged 80 and above was taken as the denominator. The results of these models did not show the existence of a consistent relationship between asset returns and demographic variables. Again, a few coefficient estimators proved to be significant, but they do not indicate any systematic link. Additionally, to check the robustness of the results, shocks were computed using a AR(*p*)-model, now allowing for $p \leq 3$. A re-estimation of all variations of the regression models shows that various coefficient estimators for the demographic variables change in magnitude as well as in sign.

One might argue that some of the examined asset markets, especially those for real estate, are not information efficient. Therefore, instead of shocks, changes of the variables were also used as explanatory variables in the regressions. All regressions described above were also run with nominal returns as the response variable and inflation as an additional macroeconomic factor. Controlling for cointegration was also tried. None of these tests resulted in any convincing empirical evidence of a relationship between demographic factors and returns.

VIII Conclusion

This paper analyzes the interrelation between demographic factors and asset returns in the G7-countries to verify the Asset Meltdown hypothesis empirically. Demographic factors were regressed on real asset return controlling for changes in the macroeconomic environment. To capture only unexpected changes, shocks for both demographic and macroeconomic variables were used in the regressions. None of the various estimation results provided evidence for a systematic relationship between demographics and asset markets.

These findings could be due to various causes. The variation of the demographic variables is quite small and identifying relationships between two variables, of which at least one is rather stable, is generally a challenging problem. A second reason could be the construction of the shocks. It is quite possible that the market participants do not react to unexpected changes in demographics of a small order of magnitude. Instead, they might react to changing appreciations of the economic impact of aging societies which are not captured by the times series used here.

We can neither prove a decrease in asset returns as a result of an aging society, nor can we empirically disprove the existence of a relationship between asset returns and demographic structure. Nevertheless, within the limitation of our models, the results suggest that Asset Meltdown is fiction rather than fact.

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