# Examining the Impact of Demographic Changes on Stock Market Prices and Equity Performance

Jake Smith

1902304

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# Abstract

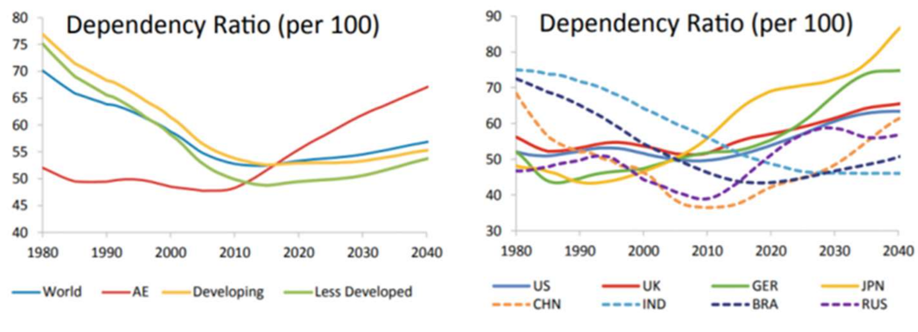
In this paper I undertook an empirical analysis to examine the impact of changing demographics on equity prices and performance. I found strong supporting evidence for the life-cycle hypothesis and its effect on the equity market. This is seen by the significance of the average age of the population in predicting equity price performance. Evidence supporting the overlapping-generations model, pertaining to the ratios of age groups in the population, is weaker while still present. More data is required to come to a definitive conclusion on this area. My findings suggest that models predicting future equity returns should account for the rapidly changing future demographic environment.

# Introduction:

From the industrial revolution until today, the Human population and its demographic makeup have undergone a significant transformation. Population growth has been shown to be endogenous, closely correlated with per capita income (Ray, 1998). This has been coined by social scientists as the demographic transition. This demographic transition begins with population growth rapidly increasing as per capita income increases due to industrialisation. However, as per capita income continues to increase, at a certain level population growth begins to fall again. This fall continues to the point where many of the world's most industrialised countries' families have fewer than two children on average. At this rate, with no immigration, the total population would begin to fall.

Advancements in healthcare were particularly important for changes in demographics. Child mortality in the UK has fallen from 329 per 1000 in 1800 to just four per 1000 in 2020 (Statista). This fall in child mortality has been replicated across many nations as they industrialise. It allowed populations to grow at a rapid rate as changes in birth rates lagged behind changes in child mortality. The fall in child mortality in combination with increased education levels and the introduction of women into the workforce led to the fall in fertility rates. Within the same timeframe, 1800 to 2020, fertility rates in the UK fell from 4.97 to 1.75 (Statista). This can be explained by the notion that families had more children due to the high likelihood that some of them would not make it to adulthood. With the fall in child mortality, it became less attractive to have as many children as was historically normal.

This trend reversed shortly during the post-world war two period. Fertility rates in the UK were 1.79 in 1935 but then quickly rose to 2.81 by 1965 and then promptly fell again. This spike, now labelled the 'baby-boom', has massive implications for the demographic outlook of the modern world. As this 'baby-boom' generation reaches retirement age, the dependency ratio is expected to rapidly grow in the coming decades. The dependency ratio describes the ratio of economically productive agents to economic agents that do not work. As the proportion of the working-age population begins to shrink, this could have profound impacts on the economies of many industrialised nations.




(The Great Demographic Reversal: Ageing societies, waning Inequality and an Inflation Revival by Charles Goodhart and Manoj Pradham, page 43)

In this study, I am aiming to analyse the impact these demographic changes will have on one of the most popular investment vehicles; equity. There are many variables that have an effect on the performance of equity, but with the coming historic shift in demographics, should demographic variables be accounted for? There has been research on this topic in the past. I will discuss the implementation of demographics into theoretical economic models before analysing others' findings on the effect of demographics on equity performance. This will coalesce in me undertaking my own empirical study into the effect of changing population structure on equity prices and performance.

# Literature Review:

## Integration of Demography into Theoretical Economic Models

Over the 20th century, there have been multiple hypotheses and theoretical models put forward to explain the tendencies of economic agents at different points of their life. The life-cycle hypothesis (Modigliani and Brumberg 1954; Ando and Modigliani 1963) attempts to describe an individual's consumption pattern over their lifetime. It states that agents pursue a steady rate of consumption throughout their lifetime by borrowing when they are young and their income is low, saving when their income is larger during their middle age, and then spending these savings once they have retired. Additionally, Coale and Hoover (1958) constructed the dependency hypothesis. It postulated that as agents increased the number of young dependents they had, their overall consumption would have to increase, resulting in a decreased savings rate.

The first economic model to account for the varying behaviours of economic agents across age groups was the overlapping-generations model (OLG), first developed by Allais (1947) and later popularised by Samuelson (1958). It characterised an economy where the life-cycle of an economic agent consists of two distinct periods. Agents supply labour in their first period, during their youth, and do not work in the second period whilst they are of old age. Therefore, the OLG model describes individuals having to maximise lifetime utility with an intertemporal budget constraint.

These theoretical models and hypotheses form the basis of multiple theoretical and empirical studies into the effects of demographic changes on stock market prices and equity performance. They chronicle the micro-foundations that determine the demand for risky assets.

## Theoretical Demographic Models Applied to Equity Prices and Performance

The OLG model has been adapted many times. In the context of demographic's effect on equity prices and performance, Abel (1999) modifies Diamond's (1965) neo-classical OLG model to allow for random-population growth and varying costs of producing capital. Consequently, the price of capital goods can shift. A key finding is that the price of capital increases as a large birth cohort reaches the labour force and reverts to the long-run mean price as this large cohort retires. Abel (2001) builds on this by including intergenerational wealth transfer after the death of an economic agent. This study couldn't provide conclusive evidence against the idea that a demographic shock (baby boom) leads to a reversion of asset prices, after their rise, once the large cohort dies. Abel (2003) includes social security in his model; finding that social security affects the amount of national savings and investment, but does not affect the long-run price of capital.

Additionally, Geanakoplos et al. (2004) investigate "the equilibria of a cyclical, stochastic, overlapping- generations exchange economy, calibrated to the stylized facts of agents' lifetime income patterns, the payoffs of securities, and the demographic structure in the United States during the postwar period" (Geanakoplos, J., Magill, M., & Quinzii, M. "Demography and the Long-Run Predictability of the Stock Market". Brookings Papers on Economic Activity, 2004, p 243). The authors analyse the effects of the changing demography on equity prices and performance using the price to earnings (PE) ratios and rates of return. This results in their models showing that changes in the middle-aged to young adults ratio induce substantial fluctuations in equity PE ratios, which when high tend to be followed by low rates of return. Since the fluctuations in PE ratios are well synchronised with the demographic cycle, they argue this supports their hypothesis that due to life-cycle behaviours demography is a significant driver of equity performance.

## Empirical Analysis on the Effects of Demographics on Equity Prices and Performance

Bakshi and Chen (1994) empirically study the effect of the life-cycle hypothesis on stock market prices. They use the average age of the US population over 20 years old. To measure the prices of equity, the S&P 500 index is used. A key finding was that the risk aversion of an agent increases as they age. Additionally, their model suggested that the average age of the population was a statistically significant predictor of both equity prices (after 1945, when there was a large increase in births) and their risk premiums. As the coefficient for the average age is positive, this suggests that as ages rise, equity prices increase. This supports the life-cycle hypothesis. However, this model doesn't account for the dependency hypothesis or the possibility that the number of retirees may hurt equity prices. To do this, a model should account for the size of different age groups in relation to one another. This may be important to the model's accuracy as Higgins and Williamson (1997) have provided evidence for the dependency hypothesis; showing that the savings rate increases as the number of youth dependents in a population declined.

Poterba (2001) attempts to account for the demographic structure of a population by looking at the level of asset ownership across different age groups and using this to predict how levels in asset ownership change as agents age. Moreover, this is used to empirically analyse the link between demographic structure and the five-year non-overlapping returns on equity. The author uses cross-sectional data from the USA, Canada and the UK. Despite the theoretical models' predictions, this study struggles to find a statistically significant relationship between demographics and stock market returns. However, the model struggles with a low amount of degrees of freedom due to the limited amount of data available. Poterba (2001) comes to the conclusion that demographic changes do not have a substantial effect in comparison to other shocks to markets. He hypothesises that the retirement of the baby-boom generation will not lead to a large fall in asset demand as "asset decumulation in retirement takes place much more gradually than asset accumulation during working years" (Poterba, 2001, p.583 of The Review of Economics and Statistics, Vol. 83).

Contrary to Poterba, Ang and Maddaloni (2005) come to a different conclusion. They use regression analysis to empirically examine the link between demographic changes and excess returns using cross-sectional data from fifteen developed economies. Short and long-run predictability (1, 2 and 5 years) of risk premiums are predicted using robust Hodrick (1992) standard errors. To conclude, they find strong empirical evidence that excess returns can be predicted using demographic changes. Their model finds the most influential variable for forecasting international excess returns is the change in the proportion of retired persons as a fraction of the adult population. As this variable increases, the equity premium is significantly predicted to fall in both the short and long run. They also determine that this effect is "strongest for countries with high levels of social security benefits and for countries with less-developed financial systems" (Ang and Maddaloni, 2005, The Journal of Business 78, no. 1, p.373).

## The Difference Between Findings Internationally and the USA

Ang and Maddaloni (2005) found that their predictions were most accurate when using international data when in comparison to data from the USA. Ang and Madaloni (2005) note that "the changes of demographic variables in other countries are lowly correlated with the US and the degree of stock market participation in some other countries is also quite different to US experience"(Ang and Maddaloni (2005) The Journal of Business 78, no. 1, p. 373). This resulted in the average age of the US population weakly predicting excess returns for US equity. Thus the inclusion of international data provides a more robust analysis of the effects of demographics on equity performance. Poterba (2001) notes this flaw in his study himself; he said that equity returns are exogenous for open economies as capital is able to flow internationally. Therefore, it is global demography that should matter. While there is a home bias in equity ownership (French and Poterba, 1991), capital flows and global demographic trends should be accounted for rather than isolating data from a specific nation's population structure and capital markets.

Goyal (2004) looks at the effect a group of six advanced economies' changing demography has on international capital flows into the USA and the resultant excess stock market returns. He does find some evidence supporting the lifecycle hypothesis. As the number of middle-aged within the populations increased, there was a statistically significant increase in net investments into the US. On the other hand, the model also suggests that there is a statistically insignificant increase in net investments into the US as the number of old aged people increased, which is contrary to the lifecycle hypothesis. Withstanding this, the addition of international demographic changes does still improve the accuracy of his regression model predicting capital inflows and outflows. Therefore, the literature seems to suggest that international demographic changes of open economies affect equity prices and performance due to the ability of capital to flow across borders.

## Returns Time Frame: Does the Market Anticipate Demographic Changes?

Poterba (2001) proposed that if agents were rational they would forecast future demographics decades in advance and factor this into their equity valuations today, negating the future returns. However, Geanakoplos et al. (2004) came to the conclusion that when agents are rational, stock prices increase more than proportionally to the growth of the middle-aged population, this effect is larger than when agents are assumed to be myopic.

Lührmann (2006) studies the effect of changing demographics on international capital flows. She finds a rising youth dependency rate is shown to affect capital outflows negatively, which provides an indication that domestic investment may increase given the anticipation of a larger future labour force and hence a larger demand for capital. Lührmann (2006) also notes that the anticipatory effects depend on international capital mobility and the development of the domestic market. Narciso (2010) builds on Lührmann's (2006) work by not only empirically studying the direction and volume of capital flows, but also the effect of demographics on the types of capital flows. Most relevant to my research on equity prices being foreign portfolio investment (FPI). Narciso studies the capital flows from source countries (eight developed economies) to host nations (38 developing economies). His model reinforces Lührmann's (2006) findings that the demographic structure of a country in the present and the future have a statistically significant impact on current international capital flows. However, importantly the model implies this is only applicable to FDI and to a much lesser extent, FPI. The author attributes this to the idea that FDI is a long-term capital flow, while FPI is intended for the short to medium term. Narciso (2010) therefore seems to provide evidence supporting Geanakoplos et al. (2004); rational agents do not bid up equity prices decades before demographics cause capital inflows, as Poterba (2001) predicted.

Dellavinga and Pollet (2007) come to a similar conclusion when studying the effect of demographics on the returns on equity across various industries. They looked at how equity performed when long-run shifts in demand could be accurately forecasted. For example, when a large cohort is born it could be said that the future demand forecasts for old age care homes would increase, which would then be translated into increased returns on equity of companies providing those services. US demography, consumption, and equity data are used. They came to the conclusion that long-term forecasted demand growth due to demographics does increase the return on equity and this is incorporated into equity prices. However, they explain that they believe investors are short-sighted and ignore predicted demand growth beyond a four to the eight-year horizon.

## Literature Review Summary

On the whole, the literature seems to support the idea that demographics have a statistically significant impact on equity prices and performance. Furthermore, the life-cycle hypothesis is supported in the findings of the majority of the empirical studies. This is often reflected by a positive correlation between equity prices and the size of the middle-aged population. Additionally, the literature suggests that the US stock market behaves differently to demographic changes in comparison to other countries' stock markets. This is possibly due to the ability for capital to flow across borders and the differences between financial market development and the social security offered in each nation. Lastly, the literature seems to agree that investors do not act on long-term demographic projections, even if the long-run returns on equity are predicted to increase due to demographics.

# Empirical Model Outline:

To measure equity prices and performance I will run a regression predicting the changes in the logged price of equity ($Log[\Delta Y_{t+q}]$ ). This will be measured over the short, medium and long term (q will take the value of 1, 2, 5, 8 and 10 years) to test the conclusions of Dellavinga and Pollet (2007) and Narciso (2010) showing investors are short-sighted to demographic shocks. The time-horizon (q) will have a minimum value of 1 year, therefore demographic variables measured at time t are able to be observed by investors.

$$Log[\Delta Y_{t+q}] = \beta_0 + \beta_1 MA_t + \beta_2 AA_t + \beta_3 SPR_{t+q-i} + \beta_4 Cgr_{t+q-1} + \varepsilon_{t+q}$$

The first demographic measure I'll be using will be the proportion of the population between the ages of 20 and 64 years old (MA). MA will be a variable capturing the proportion of the population of working age. They are more likely to be saving and investing a proportion of their income into the equity market. This should also capture the effect of the non-working population (youth dependents aged 0-19 and retirees aged 65+ are equal to one minus MA) on equity returns. If my models return a positive coefficient for MA ($\beta_1$), it would be supporting evidence for the economic theory that those at or around their peak earnings boost equity prices and returns by bidding up equity. According to the life-cycle hypothesis and the overlapping-generations model, when the proportion of the population of working age increases, so will the demand for equity as savings levels in the population should also increase.

The second demographic variable in my model will be the average age of the population above 20 years old (AA). Bakshi and Chen (1994) showed evidence that this is a significant predictor of the risk appetite of the population as those aged 20 years and above tend to hold capital. This is because it is thought that as individuals near retirement, there is a tendency for risk appetite to decrease to protect wealth from volatile changes. Hence, those of old age are predicted to hold less of their wealth in equity than their younger counterparts. For this reason, it is expected that this variable should return a negative coefficient for AA ($\beta_2$).

As there are variables that will affect equity prices and performance other than demography, I'm including some control variables where the data is obtainable. The first is the spread rate ($SPR_{t+q-i}$). This is the difference between the interest rate on long and short-term government securities and is used as an indicator that a recession may be imminent (Estrella and Hardouvelis, 1991). The 10 Year/3 Month spread rate is used where possible. Where the data wasn't available the 10 Year/2 Year spread rate was used. It is taken at time t+q-i where i varies depending on the time horizon. For the time-horizons of 1, 3, 5, 8 and 10 years, i takes the values 1, 2, 2, 3 and 4 respectively.

The second control variable is the consumption growth rate ($Cgr_{t+q-1}$). The measurement is taken at time t+q-1 so that it is observed by investors at time t+q. This has been shown to be a useful variable by consumption-based asset pricing models in predicting asset prices and their returns (Campbell 2003, Bakshi and Chen 1994, Ang and Maddaloni 2005).

Initially, I will run an OLS regression with domestic data for each country I gather data from. Following comments by Poterba (2001) and conclusions by Ang and Maddaloni (2005), I will rerun the regressions with international demographic data to see if the accuracy of the models could be improved.

Since the dependent variable is lagged by q periods, the OLS model suffers from heteroskedasticity and autocorrelation of the standard errors. This is due to the overlapping of equity price and performance over q-1 data points. This results in unreliable standard errors, and consequently, t tests on regressors are incorrect. To remedy this, Newey-West standard errors (Newey and West, 1987) are used.

# Data:

The demographic data from the UK, France, Germany and Italy is from Eurostat and provides the annual population make up by age. German and Italian data is available from 1960-2021. While the UK's data is available from 1972-2019 and the French data is only accessible from 1991-2021. The demographic data from the USA is from the US Census Bureau, with annual data available from the years 1980-2010.

I calculated the consumption growth rate using data from the world bank on GDPs and the percentages of GDP used for consumption. This allowed me to calculate the consumption growth rates of the selected countries from 1972 onwards.

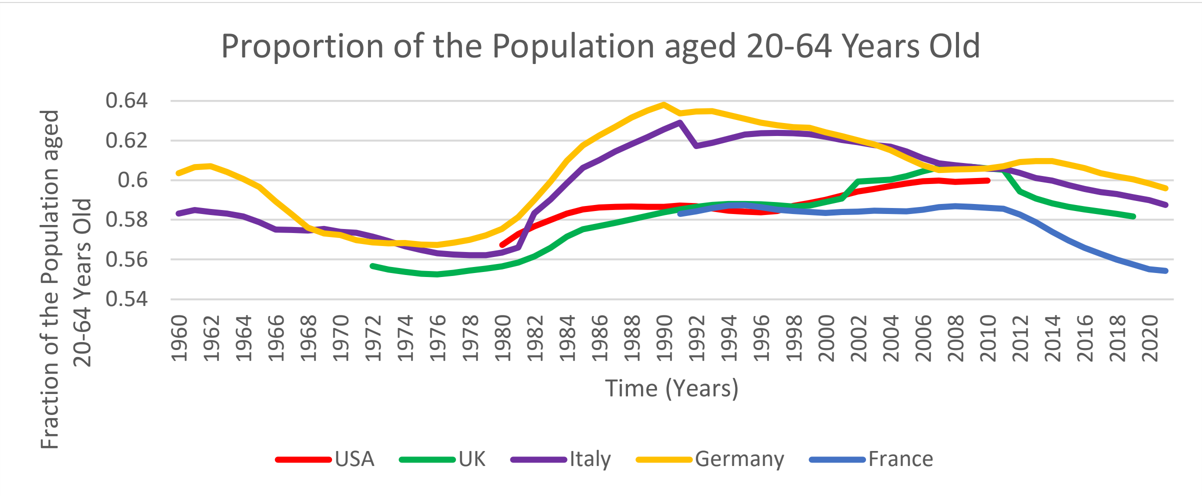
Historical bond yields were gathered from Refinitiv Datastream, although across the various countries in my study the amount of data available to me was limited. I gathered data for the yields of both 10 year and 2 year German and French government bonds from 1980 and 1991 onwards respectively. 10 year and 3 month government bond yields were available for both the USA and Italy. Bond yields for Italy were only available to me from 1991 onwards, while the US bond yields were available from prior to 1980. Unfortunately, I could not gather historical 10 year UK government bond yields. Therefore, the model proved more biased than the other countries I was studying, so I have excluded it from this study (other than the combined international demographic data across the five countries I have selected).

European equity price data is gathered from Global Financial Data. French equity prices are taken from the CAC All Tradeable index. German equity data is gathered from the CDAX Composite index. Italian equity data is from the FTSE Italia All-Share index. The S&P 500 index equity data from Macrotrends is used for the US models.

Therefore, my complete datasets for the following countries span the years: Germany 1980-2021, USA 1980-2010, France 1991-2021 and Italy 1991-2021.

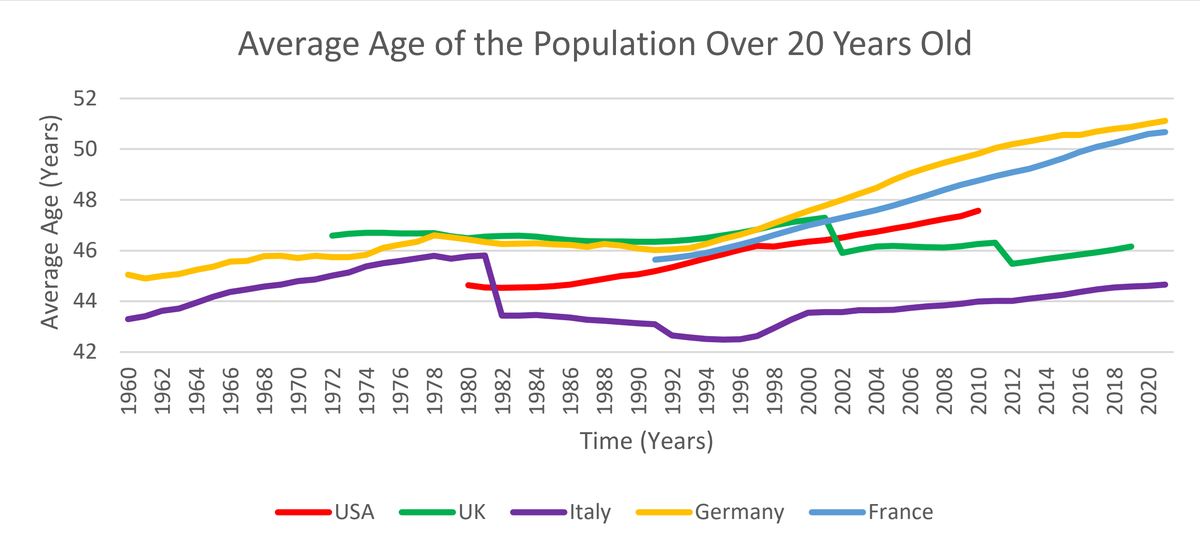
For the combined USA, Germany, UK and Italy dataset, the years covered are 1980-2010. While the dataset with the aforementioned countries with the addition of France covers the years 1991-2010.

## Data on the Proportion of the Population that is of Working Age:




The data shows a correlation between the countries. As the post-war 'baby boom' generation reached 20 years old in the 1980's, the proportion of the populations of working age rapidly increases. In Italy and Germany this effect is most pronounced. This results in the proportion of the population of working age gradually falling from their peaks in the early 1990's in both Germany and Italy. In the UK and the USA, this variable continues to grow until 2010. However from 2010 onwards, the UK, as well as France, follow the trend of Italy and Germany while the dataset for the US ends.

## Data on the Average Age of the Adult Population:



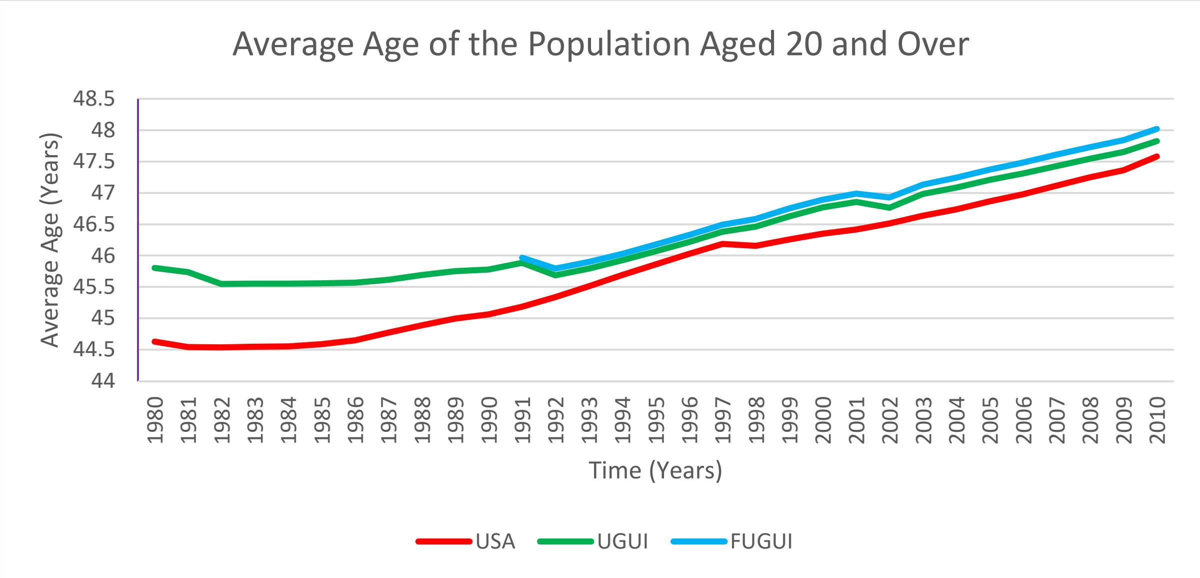

The data recording the average age of the populations from these five countries shows a pattern, as well as some outliers. The data shows a steady increase in the average age of adults in Germany, France, the USA and Italy from the early 1990s onwards.

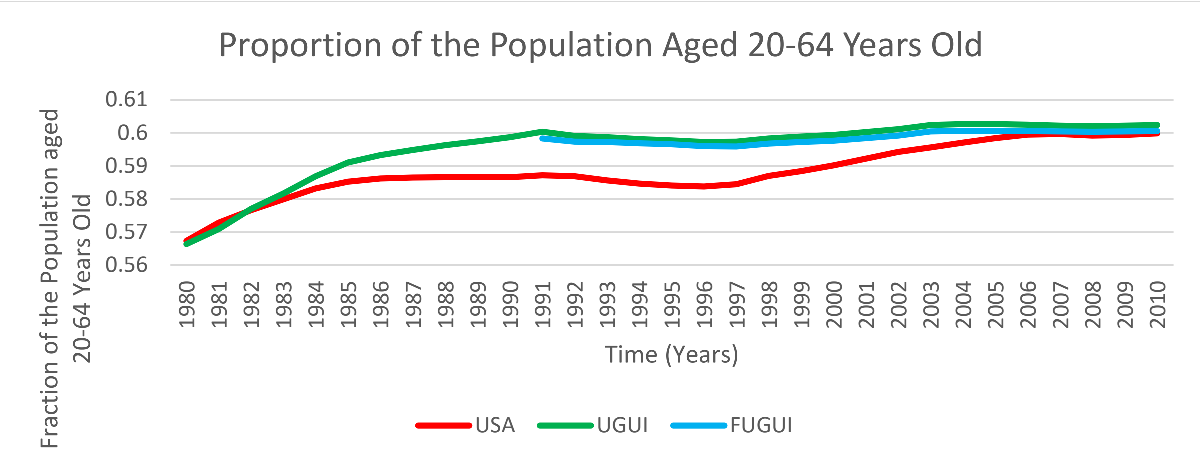
One major problem this graph highlights is the sudden and significant drop in the average age of the adult population of Italy in 1982. This fall in the average adult age seems unlikely in times absent major population changing events. The Eurostat dataset shows that the population aged over 65 in Italy falls by over 1.1 million individuals from 1981 to 1982. This may be due to a change in the method of the national survey as it seems unlikely there was this large a change in population structure naturally.

The UK data shows similar movements in the years 2002 and 2012, although to a much smaller extent. It is, therefore, less clear whether this is a natural shift in the average age of the adult population or not. When comparing this graph with the graph plotting the proportion of the population aged 20-64 years old; there is a sudden increase in the year 2002 and a sudden decrease in the year 2012. It is therefore plausible that in the year 2002, a large birth cohort reaches the age of 20, decreasing the average age of those 20 years and older. Likewise, in 2012, it is possible a relatively large amount of elderly deaths caused the average age to fall.

## Combining the Countries' Demographic Data:

Following my research of the literature on this topic, several researchers found that in their models the USA performed differently in comparison to other countries. As Poterba (2001) suggested, equity performance may be endogenous due to the ability of capital to flow across borders. As the largest equity market, this may be why the US equity is an outlier in these studies. In my study, I am therefore investigating whether the combination of multiple countries' demographics can improve the predictive ability of my model on the US' equity market, as well as other countries' stock markets. FUGUI represents the combined demographics of France, the UK, Germany, the USA and Italy. UGUI contains all of the previous countries' data, but excluding France (as annual demographic data for France is only available from 1991).




The FUGUI dataset, in comparison to the US demographic dataset, increases both the average age of the adult population and the proportion of the population aged between 20-64 years old. Additionally, the proportion of the population of working age of the combined UGUI countries continued to rise in the second half of the 1980s, while the US' proportion of the population of working-age remained stable. The proportion of the population aged between 20-64 years old in the USA begins to rise again in the late 1990s, bringing the USA in line with the combined UGUI and FUGUI figures by the end of the data set in 2010.

# Empirical Results using Domestic Demographics:

## Germany:

| Time Horizon (q) | $MA_t$ | $AA_t$ | $SPR_{t+q-i}$ | $CGR_{t+q-1}$ | Constant | Adj. $R^2$ |
|---|---|---|---|---|---|---|
| 1 Year | -0.153<br>(0.797) | -0.013<br>(0.009) | 0.024<br>(0.018) | -0.002*<br>(0.001) | 0.735<br>(0.693) | 0.03916 |
| 3 Years | -3.221<br>(2.429) | -0.05***<br>(0.015) | 0.096**<br>(0.042) | -0.001<br>(0.002) | 4.373**<br>(1.885) | 0.247 |
| 5 Years | -3.712<br>(2.343) | -0.049**<br>(0.018) | 0.013<br>(0.045) | -0.001<br>(0.001) | 4.783***<br>(1.312) | 0.1178 |
| 8 Years | -3.985**<br>(1.577) | -0.053**<br>(0.023) | -0.065*<br>(0.037) | -0.00001<br>(0.0003) | 5.122***<br>(1.298) | 0.1969 |
| 10 Years | -5.347***<br>(1.43) | -0.069***<br>(0.019) | 0.099**<br>(0.039) | 0.0003<br>(0.0002) | 6.691***<br>(1.26) | 0.3592 |

Note: *p<0.1; **p<0.05; ***p<0.01

The variable AA is shown to be a significant predictor of the change in the logged price of equity in Germany every time-horizon, other than only 1 year. It is significant to the 1% level over a three and ten-year time-horizon, as well as being significant to the 5% level over a five and eight-year time-horizon. The regressor is having the expected effect that the economic theory suggested.

On the other hand, the MA variable is statistically insignificant unless there is a long-term time-horizon. This variable is significant to the 5% level over an eight-year time-horizon and significant to the 1% level over a ten-year time-horizon. However, the variable is having the opposite effect on equity price and performance that the economic theory suggested.

The adjusted $R^2$ value is lowest for the model predicting price performance over a one-year time-horizon. This suggests that neither of the demographic regressors are significant indicators of equity performance over the short-term. While the adjusted $R^2$ value is highest when the model is predicting price performance of a ten-year time-horizon.

## Italy:

| Time Horizon (q) | $MA_t$ | $AA_t$ | $SPR_{t+q-i}$ | $CGR_{t+q-1}$ | Constant | Adj. $R^2$ |
|---|---|---|---|---|---|---|
| 1 Year | -1.302<br>(3.239) | -0.046<br>(0.044) | -0.011<br>(0.016) | -0.002*<br>(0.001) | 2.835<br>(3.822) | 0.03166 |
| 3 Years | -6.581<br>(7.127) | -0.19<br>(0.113) | -0.045***<br>(0.013) | -0.002<br>(0.002) | 12.45<br>(9.106) | 0.2261 |
| 5 Years | -16.678***<br>(3.743) | -0.368***<br>(0.041) | -0.076***<br>(0.02) | -0.002<br>(0.001) | 26.471***<br>(3.709) | 0.5521 |
| 8 Years | -15.194*<br>(8.534) | -0.384***<br>(0.063) | -0.094***<br>(0.016) | -0.001<br>(0.001) | 26.284***<br>(7.761) | 0.643 |
| 10 Years | 11.599<br>(19.251) | -0.162<br>(0.234) | -0.061**<br>(0.027) | -0.005**<br>(0.002) | 0.164<br>(21.666) | 0.6729 |

Note: *p<0.1; **p<0.05; ***p<0.01

In Italy, the variable AA is found to be statistically significant to the 1% level in predicting equity price performance for the five and eight-year time-horizons. Conversely, the MA variable is a statistically significant predictor at the 1% and the 10% level for the time-horizons of five and eight years respectively. However, as with the models using German data, the MA variables are having the opposite effect on equity price performance to what the economic theory predicted. On the other hand, the variable AA is having the expected effect on equity price performance.

The adjusted $R^2$ values increase as the time-horizon for equity performance increases. However, neither of the demographic variables are statistically significant when the $R^2$ value is its highest, over a ten-year time-horizon.

## France:

| Time Horizon (q) | $MA_t$ | $AA_t$ | $SPR_{t+q-i}$ | $CGR_{t+q-1}$ | Constant | Adj. $R^2$ |
|---|---|---|---|---|---|---|
| 1 Year | -2.987 | -0.026 | 0.018 | -0.003* | 3.014 | 0.08666 |
| | (2.355) | (0.017) | (0.021) | (0.002) | (2.092) | |
| 3 Years | -10.797*** | -0.101*** | 0.133*** | -0.001 | 10.995*** | 0.3683 |
| | (1.794) | (0.019) | (0.023) | (0.001) | (1.834) | |
| 5 Years | -15.34*** | -0.124*** | 0.156*** | -0.002** | 14.804*** | 0.6015 |
| | (2.466) | (0.019) | (0.021) | (0.001) | (2.236) | |
| 8 Years | -23.856*** | -0.09*** | -0.04 | -0.003*** | 18.525** | 0.6585 |
| | (11.087) | (0.019) | (0.027) | (0.0004) | (7.22) | |
| 10 Years | -38.477** | -0.08*** | -0.12*** | -0.003*** | 26.767*** | 0.7567 |
| | (13.89) | (0.014) | (0.021) | (0.0001) | (7.624) | |

Note: *p<0.1; **p<0.05; ***p<0.01

The AA variable is statistically significant to the 1% level over each time-horizon, other than the short-term one-year period. Furthermore, it is having the effect that the economic theory suggested. Likewise, the variable MA is statistically significant to the 1% level over all the time-horizons other than when q is equal to one. However, it is having the opposite effect to what the economic theory suggested. As with the results from Italy, the model is better at predicting the long-term equity price performance over the short term. The adjusted $R^2$ values increase as the time-horizon increases.

## USA:

| Time Horizon (q) | $MA_t$ | $AA_t$ | $SPR_{t+q-i}$ | $CGR_{t+q-1}$ | Constant | Adj. $R^2$ |
|---|---|---|---|---|---|---|
| 1 Year | -1.775 | -0.004 | 0.019** | -0.0001 | 1.243* | 0.102 |
| | (1.173) | (0.016) | (0.009) | (0.001) | (0.64) | |
| 3 Years | -1.315 | -0.042** | 0.037*** | -0.001 | 2.742 | 0.2099 |
| | (1.21) | (0.018) | (0.011) | (0.001) | (0.847) | |
| 5 Years | 2.938 | -0.112*** | 0.041** | -0.002 | 3.556** | 0.2408 |
| | (2.102) | (0.053) | (0.02) | (0.001) | 1.516 | |
| 8 Years | 2.6 | -0.152** | -0.003 | -0.001* | 5.759** | 0.2561 |
| | (2.447) | (0.071) | (0.014) | (0.0004) | (2.364) | |
| 10 Years | 1.242 | -0.13 | 0.025 | 0.0002 | 5.545* | 0.1781 |
| | (2.6) | (0.084) | (0.019) | (-0.0003) | (2.989) | |

Note: *p<0.1; **p<0.05; ***p<0.01

The AA variable is a significant predictor of changes in the price of equity over the time-horizons of three, five and eight years while having the expected effect that the economic theory suggests. It is significant to the 1% level over a five-year time-horizon, while being significant to the 5% level over a three and eight-year time-horizon. On the other hand, the MA variable is statistically insignificant in predicting changes in the prices of US equity. Consequently, the adjusted $R^2$ values are highest for the models predicting the changes in the price of equity over a three, five and eight-year time-horizon. The model is the weakest when predicting the changes in the price of equity over a one-year time-horizon.

## Summary on the models using domestic demographics to predict the price performance of Equity:

The average age of the population aged 20 years and older proved statistically significant across all countries when predicting changes in equity prices over the medium term. It was statistically significant to at least a 5% level across every model for each country over a time-horizon of five years. Additionally, it regularly proved a statistically significant indicator when the time-horizons of equity price performance were three and eight years while occasionally proving significant over a ten-year time horizon for particular countries. For this reason, I agree with previous studies concluding that the average age of the population aged 20 years and older is a good indicator of the risk tolerance of the investing population.

On the other hand, the proportion of the population aged between the ages of 20-64 years old had varying effects across the models. Firstly, in the domestic models, this variable occasionally proved statistically significant. But when it did so, it was having the opposite effect on the dependent variable that the economic theory predicted. This could be the cause of the economic theory being incorrect. Or it could be that the domestic proportion of the working age population is a weak indicator of changes in equity prices, whilst also being correlated with an unobserved variable that is negatively correlated with changes in equity prices.

Furthermore, the demographic variables were found to be most statistically significant over the medium and long-term, while almost never significant in the short term. This resulted in the models with a one-year time-horizon being consistently the least effective models, shown by the low adjusted $R^2$ values.

## What could be causing $MA_t$ to have negative coefficients?

Other than the variable having the opposite effect than the theory predicted, it could be due to MA having a weak effect on the price performance of equity while simultaneously having a correlation with an omitted variable that has a negative effect on the price of equity. Of the data I have access to, there is a correlation between demographics and 10 year government bond yields. Large bond yields have a negative effect on the demand for equity, which would affect equity price performance. This is visible through the risk premium, which is the difference between the expected return of equity and the risk free rate of return (yield on a government bond). This represents the payoff for investing in the higher risk asset, equity.

The following table shows the correlation between the 10 year bond yield of each country with each of the demographic variables MA and R where: the proportion of the population aged 20-64 years old is MA and the proportion of the population aged 65 and above is R.

| Country(s) | MA | R |
|---|---|---|
| France | 0.754623836 | -0.9377127 |
| Germany | 0.28019221 | -0.9176374 |
| Italy | 0.733654893 | -0.9052672 |
| USA | -0.3025292 | 0.286201 |

France and Italy show a strong positive correlation between MA and the respective yields on their 10 year government bonds. This could explain the high adjusted $R^2$ values those two countries showed in comparison to Germany and the USA. The German data also shows a positive correlation between MA and the 10 year German government bond yield and a strong negative correlation between R and the 10 year German government bond yield.

Consequently, with the MA variable being positively correlated with 10 year government bond yields in France, Germany and Italy, this could explain why the negative statistically significant coefficients were returned. As MA increases, so do bond yields; this in turn lowers the risk premium which lowers the incentive to invest in equity over government bonds. On the other hand, the correlation between the 10 year US government bond yields and the US MA variable shows the opposite, a negative correlation. This would also explain why the MA variable in the US models did not return a statistically significant MA coefficient, further supporting the theory that the domestic MA variable is a weak predictor of equity price performance.

### Is this correlation or causation?

As seen from the table above, the proportion of the population aged 65 and above in France, Germany and Italy is highly negatively correlated with the yield of their respective 10 year government bonds. Therefore, there is a strong tendency for 10 year government bond yields to decrease as there is an increase of individuals at retirement age. As the yield of bonds decrease, the price of bonds are increasing.

There is economic theory that suggests this relationship may be causal. The average age of the adult population has been described as an indicator of a populations risk tolerance (Bakshi and Chen, 1994), where increasing age is believed to decrease risk tolerance. This is because when economic agents reaches retirement, they are no longer earning an income so they fund their consumption through their savings. This causes dissaving in the later stages of agent's lifecycle, described by the life-cycle hypothesis (Modigliani and Brumberg 1954; Ando and Modigliani 1963). When dissaving it is economically rational to sell investments in equity due to its volatility. It would harm a retiree if there was a stock market downturn in the late stages of an individuals life-cycle. However, their capital would earn a higher return if it was invested in safe assets such as government bonds, rather than earning interest in a savings account with a bank. Retirees may consequently cause downwards pressure on bond yields, as when bond prices are bid upwards yields fall. Therefore, when the proportion of the population that are retired is increasing, risk premiums decrease for the rest of the investing population. This describes the mechanism in which demographics can cause changes in bond yields and hence the demand for equity.

# Empirical Results using International Demographics Data:

The combined demographic data of France, the UK, Germany, the USA and Italy (FUGUI) is tested on the equity market of each country below. The dataset covers annual data from the years 1991-2010.

## USA - FUGUI:

| Time Horizon (q) | $MA_t$ | $AA_t$ | $SPR_{t+q-i}$ | $CGR_{t+q-1}$ | Constant | Adj. $R^2$ |
|---|---|---|---|---|---|---|
| 1 Year | -29.172* | 0.034 | 0.031* | 0.0004 | 15.822* | 0.1094 |
| | (15.978) | (0.039) | (0.015) | (0.001) | (8.127) | |
| 3 Years | -42.867* | 0.022 | 0.066*** | -0.0003 | 24.617* | 0.2732 |
| | (23.134) | (0.045) | (0.012) | (0.001) | (12.674) | |
| 5 Years | 75.935* | -0.285** | 0.077*** | 0.005*** | -32.030 | 0.4355 |
| | (41.475) | (0.101) | (0.013) | (0.001) | (20.755) | |
| 8 Years | 76.907* | -0.195 | -0.010 | -0.004*** | -36.623* | 0.5227 |
| | (38.845) | (0.133) | (0.032) | (0.001) | (17.386) | |
| 10 Years | 39.467* | -0.025 | -0.027 | -0.005*** | -22.070** | 0.5239 |
| | (19.066) | (0.067) | (0.016) | (0.001) | (8.629) | |

Note: *p<0.1; **p<0.05; ***p<0.01

With the addition of the FUGUI demographic dataset to the model, the adjusted $R^2$ values are now significantly larger than when using US only data. However, the AA variable is only statistically significant (to a 5% level) when the time-horizon is five years. The variable MA is significant to the 10% level for all-time horizons. This variable was not statistically significant across any time-horizons when using US only data. Although, the coefficients are negative for the time-horizons of one and three years, whereas they are positive for the time horizons of five, eight and ten years.

## Germany – FUGUI

| Time Horizon (q) | $MA_t$ | $AA_t$ | $SPR_{t+q-i}$ | $CGR_{t+q-1}$ | Constant | Adj. $R^2$ |
|---|---|---|---|---|---|---|
| 1 Year | 28.363 | -0.105 | 0.059* | -0.001 | -12.086 | -0.06783 |
| | (24.765) | (0.079) | (0.031) | (0.001) | (11.523) | |
| 3 Years | 113.072*** | -0.407*** | 0.195*** | -0.001 | -48.732*** | 0.4687 |
| | (28.710) | (0.077) | (0.034) | (0.001) | (14.137) | |
| 5 Years | 167.390*** | -0.482*** | 0.043 | -0.006*** | -77.476*** | 0.1596 |
| | (50.504) | (0.111) | (0.042) | (0.001) | (25.618) | |
| 8 Years | 125.899*** | -0.337*** | 0.010 | -0.003** | -59.369*** | 0.4436 |
| | (19.536) | (0.053) | (0.057) | (0.001) | (9.981) | |
| 10 Years | 44.435** | -0.121** | 0.110* | -0.002*** | -20.862* | 0.3557 |
| | (20.656) | (0.045) | (0.056) | (0.001) | (10.614) | |

Note: *p<0.1; **p<0.05; ***p<0.01

The inclusion of the FUGUI demographic data has improved the predictive ability of the German model (other than over a one year time-horizon). This is seen by the higher adjusted $R^2$ values. Additionally, both the demographic regressors are significant to the 1% level over the three, five and eight year time-horizons and significant to the 5% level over a ten year time-horizon. Furthermore, they are now both having the effect on equity that the economic theory predicted.

## France - FUGUI

| Time Horizon (q) | $MA_t$ | $AA_t$ | $SPR_{t+q-i}$ | $CGR_{t+q-1}$ | Constant | Adj. $R^2$ |
|---|---|---|---|---|---|---|
| 1 Year | 36.077 | -0.106 | 0.030 | -0.006** | -16.583 | 0.04755 |
| | (30.412) | (0.076) | (0.027) | (0.003) | (14.942) | |
| 3 Years | 65.835 | -0.319*** | 0.174*** | -0.002 | -24.554 | 0.4595 |
| | (46.627) | (0.097) | (0.031) | (0.002) | (23.739) | |
| 5 Years | 68.323** | -0.366*** | 0.188*** | -0.002*** | -23.814* | 0.7513 |
| | (25.364) | (0.058) | (0.029) | (0.001) | (12.765) | |
| 8 Years | 23.194 | -0.209*** | -0.036* | -0.002*** | -3.788 | 0.6851 |
| | (15.297) | (0.047) | (0.018) | (0.0004) | (7.565) | |
| 10 Years | -24.734 | -0.050 | -0.142*** | -0.003*** | 17.664* | 0.7182 |
| | (19.107) | (0.051) | (0.012) | (0.0002) | (9.220) | |

Note: *p<0.1; **p<0.05; ***p<0.01

The addition of the FUGUI demographic data hasn't significantly changed the adjusted $R^2$ values for the models predicting changes in the price of French equity. The variable AA is a statistically significant predictor of the price performance of equity at the 1% level over a three, five and eight year time-horizon. However, when comparing it to the models using only French demographic data, it is now a statistically insignificant predictor over a ten year time-horizon. On the other hand, the MA variable is statistically significant to the 5% level, with the expected sign over a 5 year time-horizon.

## Italy- FUGUI

| Time Horizon (q) | $MA_t$ | $AA_t$ | $SPR_{t+q-i}$ | $CGR_{t+q-1}$ | Constant | Adj. $R^2$ |
|---|---|---|---|---|---|---|
| 1 Year | -9.392 | -0.022 | -0.028 | -0.002 | 6.711 | 0.05601 |
| | (30.141) | (0.087) | (0.023) | (0.003) | (14.401) | |
| 3 Years | -1.529 | -0.143 | -0.047** | -0.003 | 7.749 | 0.2798 |
| | (63.384) | (0.127) | (0.019) | (0.002) | (32.392) | |
| 5 Years | 30.168 | -0.305*** | -0.036 | -0.005** | -3.602 | 0.5465 |
| | (37.381) | (0.080) | (0.024) | (0.002) | (19.273) | |
| 8 Years | 30.217 | -0.312*** | -0.065** | -0.004*** | -3.184 | 0.7905 |
| | (20.609) | (0.073) | (0.023) | (0.001) | (10.887) | |
| 10 Years | 9.267 | -0.265*** | -0.052 | -0.005** | 7.116 | 0.6723 |
| | (33.277) | (0.070) | (0.033) | (0.002) | (17.776) | |

Note: *p<0.1; **p<0.05; ***p<0.01

The inclusion of the FUGUI demographic data to the Italian model has slightly improved the effectiveness of the models predicting equity price performance of the Italian stock market, seen in the adjusted $R^2$ values. The MA variable is not statistically significant in these models, while over certain time-horizons they were when using only Italian demographic data (although, these regressors were having the opposite effect that the economic theory predicted). However, the variable AA is now statistically significant to the 1% level over a ten year time-horizon, as well the five and eight year time-horizon (as it was with Italian only demographic data).

## Summary of Model Results using International Demographics:

The average age of the population over the age of 20 years old in the five countries of my study was significant in predicting equity price performance over medium and long term time-horizons, as it was when using only domestic data. The only country where FUGUI's AA variable had less of an effect in comparison to using only domestic data was when it was used to predict the performance of the US S&P500. However, it was still a statistically significant to the 5% level when predicting equity performance over a five year time-horizon. In each model it was having the expected effect that the economic theory predicted.

The proportion of the populations of the five countries that were aged between 20-64 years old also proved a statistically significant predictor in most models. The only country where this was an exception was Italy. However in the other countries, when the proportion of the population of working age was statically significant it had a positive effect on equity prices, as the economic theory predicted (the only omission being the US model over a one and three year time-horizon). This is in contrast to the models using domestic demographic data only.

The inclusion of international demographic data when predicting the equity price performance of each countries stock market tended to increase the adjusted $R^2$ values over each time frame. However, this may be due to the smaller FUGUI dataset. The models predicting the changes in logged equity price over the course of one year were still the weakest. The models with the addition of international demographic data show that they are most effective at predicting equity price performance over an eight year time-horizon. The adjusted $R^2$ value is highest in each country (except France) when q is equal to eight.

## Is the Increased adjusted $R^2$ Values due to a Smaller Sample?

I can attempt to test whether the FUGUI models were biased due to the sample size by removing France from the combined international demographics. This allows me to have a dataset (UGUI) consisting of annual demographic data from the years 1980-2010. I can only run this demographic dataset on the German and US equity markets due to the data available to me.

### USA - UGUI:

| Time Horizon (q) | $MA_t$ | $AA_t$ | $SPR_{t+q-i}$ | $CGR_{t+q-1}$ | Constant | Adj. $R^2$ |
|---|---|---|---|---|---|---|
| 1 Year | 0.108 | -0.029 | 0.016* | -0.0003 | 1.269 | 0.068 |
| | (2.029) | (0.024) | (0.009) | (0.001) | (0.938) | |
| 3 Years | -1.373 | -0.067 | 0.035*** | -0.001 | 4.000*** | 0.2443 |
| | (3.215) | (0.047) | (0.012) | (0.001) | (1.255) | |
| 5 Years | 4.390* | -0.161** | 0.052*** | -0.001* | 4.939** | 0.3164 |
| | (2.482) | (0.060) | (0.018) | (0.001) | (2.032) | |
| 8 Years | -0.583 | -0.131 | 0.004 | -0.0002 | 6.674** | 0.1571 |
| | (3.976) | (0.092) | (0.016) | (0.0002) | (2.968) | |
| 10 Years | -1.467 | -0.099 | 0.021 | 0.0002 | 5.767* | 0.09267 |
| | (3.756) | (0.102) | (0.023) | (0.0001) | (3.368) | |

Note: *p<0.1; **p<0.05; ***p<0.01

The UGUI demographic dataset did not significantly increase the predictive power of the model in comparison to using US only data. The AA variable has become statistically insignificant in all but the model in which the time-horizon was five years. However, both demographic variables are statistically significant with the predicted effect the economic theory suggested over this five year time-horizon. The variable MA is significant to the 10% level, while the AA variable was significant to the 5% level.

### Germany - UGUI

| Time Horizon (q) | $MA_t$ | $AA_t$ | $SPR_{t+q-i}$ | $CGR_{t+q-1}$ | Constant | Adj. $R^2$ |
|---|---|---|---|---|---|---|
| 1 Year | -1.355<br>(1.877) | -0.050*<br>(0.028) | 0.057**<br>(0.025) | -0.0003<br>(0.002) | 3.099**<br>(1.367) | 0.07839 |
| 3 Years | -10.296*<br>(5.143) | -0.018<br>(0.051) | 0.090<br>(0.054) | 0.002<br>(0.002) | 6.926***<br>(2.332) | 0.1793 |
| 5 Years | -10.468*<br>(6.084) | -0.023<br>(0.077) | 0.081<br>(0.082) | 0.001<br>(0.002) | 7.352***<br>(2.316) | 0.2053 |
| 8 Years | 547.423<br>(1,601.736) | -2.020<br>(36.263) | 49.575<br>(29.979) | 0.231<br>(0.239) | -196.607<br>(1,086.565) | 0.01791 |
| 10 Years | 1,006.330<br>(1,234.456) | 22.564<br>(30.437) | 36.099**<br>(17.301) | 0.297**<br>(0.128) | -1,577.257<br>(1,085.301) | -0.03504 |

Note: *p<0.1; **p<0.05; ***p<0.01

The UGUI demographic dataset significantly reduces the models' predictive ability in comparison to both the FUGUI dataset and the domestic German demographic dataset. This is seen in the drastic reduction of the adjusted $R^2$ values. This could be due to international demographics having little effect on the German demographic market, meaning the German models using the FUGUI model had a high adjusted $R^2$ value due to a bias created by the smaller sample size.

# Conclusion:

In this study I have examined the effects of demographics on the stock markets of the USA, Germany, France and Italy over the short, medium and long term. Domestic demographic data showed that demography had a statistically significant impact on equity price performance over the medium and long term, while being statistically insignificant over the short term. This supports the findings of previous studies (Geanakoplos et al. 2004, Dellavinga and Pollet 2007 and Narciso 2010) that show rational agents do not bid equity prices upwards decades before demographics cause capital inflows or outflows, as Poterba (2001) predicted.

Domestic demographic data on the average age of the population aged 20 years and above consistently had a statistically significant effect on equity price performance over the medium term and regularly over the long term. As the average age of the adult populations increased, equity prices were shown to decline if all other variables remained equal. This provides evidence to the life-cycle hypothesis' effect on equity prices and performance; as the average age of the adult population increases, dissaving increases creating downward pressure on equity prices. Therefore, this provide supporting evidence to previous studies of this variable (Bakshi and Chen, 1994). Theoretically, this is due to the risk tolerance in the populations declining as economic agents near retirement. With lower risk tolerances, demand for equity falls as it is naturally a volatile investment vehicle. A fall in demand for equity creates downwards pressure on prices. This effect tended to be absent over the short term, one year time horizon. This may be because equity can be volatile over the short term, with demographics providing upwards or downwards pressure over long periods.

Separately, while the proportion of the population aged between 20-64 years old was found to be a statistically significant predictor of equity price performance, when domestic demographic data was used, the variable was having the opposite effect that the economic theory suggested. I believe this could be interpreted as the proportion of the domestic population of working age, and consequently the proportion of the population of non-working age, having a weak direct effect on equity price performance. However, it could be a determinant of the prices and yields of government bonds, which have knock-on effects on equity performance due to its effect on the risk premium. The exception to this is the USA, where there was no correlation between demographics and government bond yield. Consequently, the MA variable proved statistically insignificant to equity price performance in the US.

More study is needed to determine whether this is correlation or causation, but there is economic theory (described earlier in this study) that does indicate changes in bond yields are influenced by demographics. This would explain why my models returned statistically significant negative coefficients for this variable. If the proportion of the population of working age is increasing, which in turn increases the bond yields, the attractiveness of investing in equity decreases. This is seen in the risk premium: the difference between the expected return of equity and the risk free rate of return (yield on a government bond). This therefore provides some evidence towards the overlapping-generations model. However, its direct effect on both equity prices and bond yields needs to be examined further. The relationship between demographics and risk premiums should be tested with a larger dataset as there is the possibility that the correlation between the proportion of the population of working (and non-working) age and bond yields is not causal and, by chance, are correlated due to the sample size. The relationship between the MA variable and the risk premium of equity should also be tested. However, without access to historical expected returns data I could test this relationship in this study.

When combining demographic data across France, the UK, Germany, the USA and Italy (FUGUI), improvement of the accuracy of the models, is seen in the increased adjusted $R^2$ values. The average age of the population tended to remain statistically significant over the medium and long-term. The

MA variable also returned statistically significant coefficients in all countries except Italy. Additionally, when the MA variable did return a statically significant coefficient, it was having a positive effect on equity price performance (other than the US FUGUI model over a one and three year time-horizon). This is the effect the economic theory suggested this variable would have on equity. This may indicate that international demographic make-up by age has a greater direct effect on countries' stock market than domestic demographic age proportions. This supports Poterba's (2001) prediction that equity returns in relation to demographics are exogenous, as capital is able to flow across borders. As the proportion of the international population of working age increases, total savings increase, which in turn increases capital flows between countries where there is capital mobility. This creates upwards pressure on equity prices.

On the other hand, the results from the FUGUI models may be biased due to their small sample size. I extended the sample size by excluding French demographics from the previous data set, resulting in the UGUI dataset. When applied to the German equity market, the adjusted $R^2$ values were reduced in comparison to using German only data and also the FUGUI dataset. This supports the idea that the FUGUI models may have shown bias, but it could also be the case that French demographics have a large impact on Germany equity due to their geographic proximity. When applied to the US' S&P500 index, the UGUI models had a reduced adjusted $R^2$ values when compared to the US FUGUI model. While the US UGUI models had similar adjusted $R^2$ values to the models using only US demographic data. It must be noted that the demographic regressors in the US UGUI models were only statistically significant over a five year time-horizon. More tests with larger datasets and more countries should be carried out to come to a more definitive conclusion.

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