The implications of population ageing for the stock market in the United Kingdom.

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The aim of this paper is to investigate whether population ageing has implications for the FTSE all share stock market in the UK. This paper first identifies if population ageing is occurring in the UK by examining the proportion of the population above 65, before then investigating fertility rates and life expectancy to determine if population ageing will continue. This paper then reviews the life cycle hypothesis, which suggests a theoretical relationship between demographics and the stock market exists. To identify if this is the case a time series econometric study is constructed from 1963 to 2014, using vector error correction and vector autoregression, as well as Wald Granger causality, variance decomposition and impulse response functions, to determine long run and short-run relationships. This paper finds that population ageing is in fact occurring in the UK and that there is a weak statistical relationship between the prime saving 40 to 64 cohort and the stock market, consistent with the lifecycle hypothesis. However, a relationship was not found for the population ageing 65+ cohort, suggesting that population ageing does not currently have implications for the stock market in the UK. Following these results this paper critically evaluates the reasons for statistical insignificance in the UK 65+ cohort and suggests future developments in the methodology.

1. Introduction

The aim of this paper is to investigate the implications of an ageing United Kingdom (UK) population on the FTSE all share stock market (ASX). This paper first examines if population ageing is occurring in the UK, before then investigating the lifecycle hypothesis (LCH), which suggests a relationship between demographics and the stock market exists. Following this a time series econometric study is constructed from 1963 to 2014, which uses two demographic models; the size of the 40 to 64 (40-64) cohort, which represents prime saving years, and the 65+ cohort, which represents population ageing.

Economists debate whether a relationship between demographics and the stock market exists. The LCH states that individuals aged 40-64 buy stocks in anticipation for retirement, and then upon reaching retirement age (65+) they sell to younger cohorts for income (Poterba, 2004). Therefore, if the 65+ cohort increases in size relative to the 40-64 cohort there may be an oversupply of stocks, causing prices to fall (Schich, 2009). Poterba (2004) and Brunetti and Torricelli (2010) find evidence of this relationship in previous studies on the US and Italy, however, little literature exists examining the UK. It is important to examine the UK because the proportion of the population 65+ has risen 50 per cent to 17.7 per cent over the sample period (ONS, 2015a) and is predicted to increase to 23 per cent of the population by 2035 (ONS, 2012). If a rising 65+ cohort causes the stock market to fall, UK retirees might discover their pensions are worth less than they had planned. This has implications for the government, who may be required to fund the short fall (Davis and Li, 2003), and also to stock market traders, as their profit and loss may be affected.

In order to determine if a relationship exists between population ageing and the stock market, this paper has the following structure. In Section 2 population ageing is examined to determine if it is occurring in the UK and the factors causing it, to identify if population ageing will continue. The economic theory is then examined in Section 3.1, where an overlapping generations (OLG) model is constructed to explain the LCH. In Section 3.2 previous econometric studies are examined and areas of improvement are identified, as well as previous techniques that will benefit this study.

In Section 4 the methodology is outlined. Section 4.1 examines the two demographic models used, explaining the decision to investigate the prime saving 40-64 cohort alongside the population ageing 65+ cohort. In Section 4.2 this paper explains why time series econometrics is an appropriate statistical method and also the decision to construct cointegration, vector error correction (VECM) and vector auto regression (VAR) models, instead of simple linear regression. In Section 4.3 the control variable specification is outlined and then in Section 4.4 the independent and dependent variables are defined. In Section 4.5 the demographic models are plotted against ASX returns, to provide a visual representation of whether a relationship exists between demographics and the stock market.

In Section 5.1 to 5.4 the time series econometric results are presented, and in Section 5.5 the limitations to the study are critically evaluated. This paper uses these limitations to suggest future developments in Section 5.6. In Section 6 the conclusion follows.

This paper concludes that population ageing is in fact occurring in the UK, however, it does not currently have implications on the stock market. The results for the 40-64 model were in line with the LCH, with a weak but statistically significant relationship with the ASX. However, the population ageing 65+ produces insignificant results. This paper argues this may be due to international capital flows, which prevents an oversupply of stocks in the UK and is not accounted for due to the assumption of a closed economy. It is also suggested that the 65+ cohort may not yet have reached a large enough size to affect the stock market, especially because it was found in Section 2 that the faster ageing Italian population only shows weak statistically significant results (Brunetti and Torricelli, 2010).

This paper adds value by extending the sample period to end in 2014 and by constructing a more comprehensive set of control variables, using Gordon's (1962) dividend growth model. It was found, however, that there are a number of limitations, for example the use of a dividend yield proxy to extend the sample period by thirty-four years may reduce the accuracy of the results. Furthermore, the assumption of a closed economy means this study does not account for international capital flows. Future developments include paying for access to more comprehensive databases, which may contain the actual dividend yield, and constructing a panel data econometric study, which would take into account the open economy and international capital flows. This paper also argues a higher word count would allow further econometric tests and models to be constructed, such as an autoregressive-distributed lag (ARDL) test and the ratio of 65+ to 40-64 model, which would improve the robustness of the study.

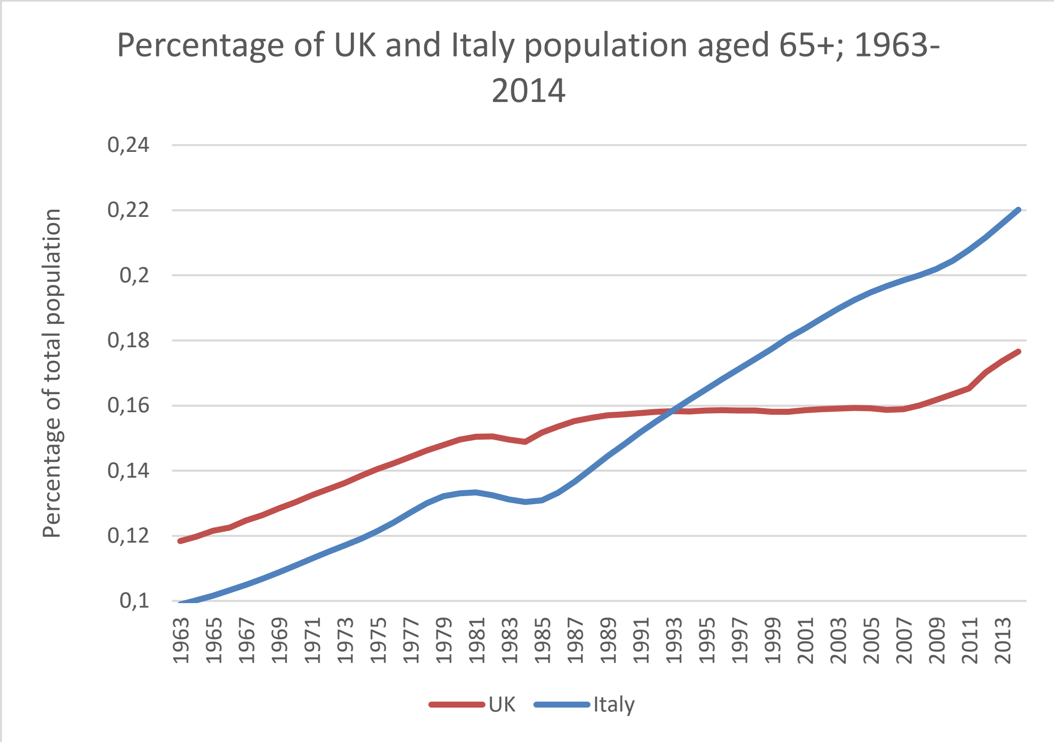
2. Demographics

2.1 Population ageing

Population ageing is defined as an increase in the proportion of the total population aged 65 and over (65+).

Figure 1 shows the UK 65+ cohort as a percentage of the total population, over the sample period 1963-2014. It is important to note that the UK dataset is constructed using different collection techniques in Northern Ireland and Scotland compared to England and Wales. This is not expected to affect the reliability of the data when examining the UK population as a whole (ONS, 2015a), it may affect, however, regional comparability.

Figure 1: Percentage of UK and Italian population aged 65+



Source(s): UK from ONS (2015a), Italy from WorldBank (2016).

In Figure 1, the 65+ UK cohort steadily rises from 11.8 per cent to 17.7 per cent over the sample period. The general upward trend in the 65+ cohort suggests that population ageing is in fact occurring in the UK.

Despite this evidence, the UK's population ageing is still behind other developed countries. Figure 1, for example, shows Italy has seen a twofold increase in the percentage of its population 65+, from 9.8 per cent to 22.01 per cent over the sample period (WorldBank, 2016). A study by Brunetti and Torricelli (2010) finds a significant but weak relationship between population ageing and the stock market in Italy. Hence, if the results for Italy are weak it could be argued that the 65+ cohort in the UK has yet to reach a level that is significant enough to have an impact on the ASX.

2.2 Causes of population ageing

Understanding the causes of population ageing in the UK is important, as it provides an insight into whether ageing will continue and if this study will be relevant in the future. In Table 1 fertility rate data is presented, which investigates whether there has been a change in the number of births in the UK. The data used is regarded as reliable, as recording childbirth has been a legal requirement since 1836 (Births and Deaths Registration Act, 1836). This paper recognises, however, there may be slight inaccuracies, for example the 42-day window to register a birth means some births are counted in the year following their actual occurrence (ONS, 2015b).

Table 1: Fertility rates, UK (births per woman)

	1960	1970	1980	1990	2000	2010
United Kingdom	2.71	2.44	1.90	1.83	1.64	1.92

Source(s): Data from ONS (2015b), rounded to two decimal places.

Table 1 shows fertility rates have fallen from 2.71 to 1.92 over the period 1960 to 2010. Goldin and Katz (2000) attribute this to the introduction of the birth control pill in the 1960s, which has lead to increased female participation in the workforce. This paper argues that the rise in the 65+ cohort from 2009 onwards, shown in Figure 1, is arguably due to the size of the 40-64 cohort born in the 1960s and 1970s declining due to the lower fertility rates.

Another explanation for population ageing is that individuals are living longer. Leon (2011) argues the UK has become healthier due to heightened awareness of health issues, such as smoking. He finds a declining number of deaths resulting from cardiovascular diseases, which has contributed to an improvement in UK life expectancy from 73.8 in 1980 to 80.9 in 2014 (ONS, 2015b). Studies investigating the theory that life expectancy will stop rising have yet to produce conclusive and significant results (NIA, 2006). Hence, this paper argues it is possible that population ageing may continue.

3. Literature Review

3.1 Economic theory

The life cycle hypothesis (LCH) provides an economic explanation for the relationship between population ageing and the stock market. The theory states that individuals seek to even out consumption over their lifetime based on current income and future income expectations (Modigliani and Brumberg, 1954). According to this hypothesis individuals become net savers in their middle years, before dissaving in retirement to produce income (Deaton, 2005). Jamal and Quayes (2015) argue this has an impact on the stock market, as the savings accumulated in their middle years include stocks, which are then sold in retirement. Bakshi and Chen's (1994) life cycle risk aversion theory enhances this effect, arguing that individuals become more risk averse with age. Therefore, retirees not only sell stocks for income, but to also transfer their wealth to less risky bonds.

A closed economy OLG model is shown in equation (1), which explains this relationship in more detail (Poterba, 2001).

$$PK = N_y S \tag{1}$$

In equation (1) individuals work towards a base good when they are young (y) and then retire when they are old. N_y is the size of the young cohort and S is the savings rate, which is constant. P is the price of capital (K) in relation to one unit of the base good and K is fixed. Therefore, taking into account the constants, a rise in the young cohort N_y will increase P. Substituting capital for stocks and this model demonstrates how the size of an age group can affect stock prices. It is argued that population ageing will cause N_y to fall, and thus P to fall.

However, this paper argues there are a number of critiques to the theory. If the efficient market hypothesis (EMH) holds then the market will have already priced in the effects of demographic ageing (Bodie *et al*. 2014). Forward-looking market participants will have anticipated population ageing when fertility rates began declining in the 1960s (see Section 2). As a result, S will decrease, due to lower expectations of future returns, and therefore it is possible P remains constant. However, this paper argues that the EMH itself is a questionable theory. If the market did not efficiently price in the housing bubble of 2007 (Ball, 2009), then it may be possible that demographic transition has also been overlooked.

Another critique stems from the assumption of a closed economy. In reality the economy is open and therefore international capital flows may ease the oversupply of stocks. This is because ageing populations will be able to sell their stocks to younger demographics in emerging economies (Poterba, 2004), consequently disconnecting the relationship between population ageing and the stock market. Brunetti and Torricelli (2010) argue that significant home bias towards stock ownership in countries such as the US, where domestic ownership accounts for 90 per cent of stocks (French and Poterba, 1991), reduces the impact of international capital flows. However, a survey by the ONS (2015c) finds that only 46.2 per cent of UK quoted shares are owned by UK individuals, suggesting international capital flows are a potential limitation to the theoretical relationship between population ageing and the stock market in the UK.

Additional empirical evidence also suggests the LCH does not occur in reality. Young (2002) and Schich (2009) investigate the UK and find no evidence of dissaving in retirement, in fact Young (2002) finds an increase in the saving rate from 10 per cent to 25 per cent. One possible reason for this is the bequest motive, where individuals retain assets in order to provide an inheritance for their children (Schich, 2009). Another is uncertainty over life expectancy. Deaton (2005) argues that tools for reviewing how individuals behave under uncertainty were not available to Modigliani and Brumberg in 1954, therefore this factor may not have been fully accounted for in their paper. However, this paper argues that the data Young (2002) and Schich (2009) present on saving rates is questionable. The Family Expenditure Survey used by Young (2002) does not fully account for the difficulties in recording pensioner income, which Miles (1999) argues is often simply a redistribution of capital. Taking this into account Miles (1999) constructs a study and finds that the UK saving rate falls eight per cent due to ageing, in line with the LCH. Therefore, the LCH may still offer an economic foundation as to why population ageing may affect the stock market.

3.2 Econometric studies

The literature on this topic uses varying econometric methodologies; from time series to panel data, and it is found in general that if a relationship exists between demographics and the stock market, it is weak. This paper found two studies on the UK, however in both cases the UK is considered as a side note to a main study on the US. Poterba (2001) uses a time series approach from 1961-1996 and finds no evidence of a relationship between the size of the 40-64 cohort and stock returns in the UK. The results show a statistically insignificant coefficient of -2.174. Davis and Li (2003) construct a panel data study covering 1950-1999 and investigate seven country's demographics against the return on stock prices. However they find a statistically insignificant coefficient of +0.007 for the 40-64 cohort in the UK. Neither of these studies construct direct tests on the 65+ cohort on the stock market.

Despite the lack of significance in these studies, this paper argues that the dividend growth model used by Davis and Li (2003), as a specification for the control variables, is a more robust method of reducing omitted variable bias than Poterba (2001, 2004), who only includes basic explanatory variables, such as GDP and interest rates. This is taken into account when constructing this paper's control variables in Section 4.

Further econometric studies on population ageing and the stock market include Brunetti and Torricelli (2010) who investigate Italy through a panel data study, from 1958-2004. They find statistical significance for 40-64 and 65+, with the coefficient signs negative at -11.452 and -11.504 respectively. The 40-64 sign is not consistent with the LCH, which this paper argues may be a result of the lifecycle risk aversion hypothesis, where individuals late in the 40-64 cohort sell their stocks for bonds (Bakshi and Chen, 1994). Further studies include Jamal and Quayes (2015) who found a statistically significant long-run relationship in their time series study for the US. This is indicated by a negative error correction term in their VECM for 65+/45-64 and 45-64. A one per cent increase in 45-64 and 65+/45-64 is associated with a 1.02 per cent increase and 0.38 per cent decrease in the price-to-dividend, respectively. These results are in line with the economic theory.

In contrast to the other studies Yoo (1994) constructs cross-Sectional regressions for the US. He investigates five age groups and finds statistically significant coefficients of +24.78 for 55-64 and -9.83 for 65+ on stock returns. However, Yoo (1994) and Macunovich (1997), who investigates eleven demographic groups, are argued by Poterba (1998) to suffer from over fitting. Varian (2014) suggests simpler models lead to better results, as over-fitting can lead to random noise becoming over exaggerated. This paper critically argues that this may be a reason for the significant results in Yoo's (1994) study.

As the results above show, US and Italy demographics appear to show statistically significant relationships with the stock market, however, the results for the UK are insignificant. As mentioned this paper draws on the strengths of Davis and Li's (2003) method and applies the dividend growth model (Gordon, 1962), as a control variable specification. Furthermore, following Yoo (1994) and Macunovich's (1997) studies this paper aims to reduce the issue of over-fitting when constructing the models in Section 4, by using concise demographic variables rather than a large array of different age groups. Additionally, this paper finds it can add value by extending the sample period beyond 1996 (Davis and Li, 2003) and 1999 (Poterba, 2001) to 2014, and by running a model for the 65+ cohort, as previous results are not available.

4. Methodology and Data

4.1 Models

$$RTN_t = \beta_1 POP40_t + \beta_2 Z_t + u_t \tag{2}$$

$$RTN_t = \beta_1 POP65_t + \beta_2 Z_t + u_t \tag{3}$$

This paper's methodology includes two models – equations (2) and (3) – that aim to explain changes in the dependent variable *RTN*, which is the real log return on the ASX. Both models include the control variables Z_t to help reduce omitted variable bias, which, if unaccounted for, may reduce the accuracy of the results (Stock and Watson, 2012).

Model I in equation (2) investigates the prime saving 40-64 cohort, which the LCH suggests will increase the demand and therefore price of stocks. An increase in this variable is expected to have a positive impact on the ASX.

Model II in equation (3) investigates the population ageing 65+ cohort. If the economic theory from Section 3 holds then an increase in this cohort will have a negative effect on the ASX. Section 2 has, however, already pointed out that the relationship between the 65+ cohort and the ASX may not yet show a statistically significant relationship, as population ageing in the UK is less pronounced than in other countries such as Italy.

This paper has chosen to include 40-64 alongside 65+, even though the main aim of this essay is investigating the implications of the population ageing 65+ on the stock market. This is because population ageing is defined as an increase in the proportion of the total population 65+, therefore an increase in the 40-64 cohort will accordingly cause the 65+ cohort to decrease in size. Due to this interconnectedness, understanding the relationship between 40-64 and the stock market provides a robust view of the implications of population ageing. Furthermore, the inclusion of the 40-64 cohort allows comparability with previous UK population ageing studies, such as Poterba (2001), allowing a more comprehensive conclusion of results. By investigating 40-64 and 65+ individually this paper also diminishes the issue of over-fitting present in studies such as Yoo (1994) and Macunovich (1997).

4.2 Method

To investigate the aim of this paper a time series econometric study is constructed. Time series is a suitable statistical method because it provides the tools to analyse a causal relationship between variables over a period of time (Stock and Watson, 2012), which is consistent with investigating the relationship between demographics and the stock market from 1963 to 2014. This paper first tests for stationarity using the Augmented Dickey-Fuller (ADF) (Dickey and Fuller, 1979) and Phillip-Perron (PP) (1988) tests. This is important because if any variables are non-stationary simple linear regression cannot be constructed, because it may lead to spurious regression (Lancheros, 2016). This occurs when the variables appear related but in fact have no causal relationship, leading to invalid results (Cohn and Kolluri, 2003). Following the discovery of non-stationary variables in the stationarity tests, this paper constructs cointegration tests. Cointegration occurs if the non-stationary variables are jointly stationary (Krätzig and Lütkepohl, 2004), therefore avoiding spurious results. This paper uses Engle-Granger cointegration and for robustness also uses Johansen's test, which has the added benefit of identifying multiple cointegrating equations (StataCorp, 2014).

After discovering cointegration a VECM test is constructed to look for long-run equilibrating relationships between the two models and the dependent variable. The study is extended further and a VAR is constructed to investigate short-run relationships. This paper tests for stability in the models and constructs impulse-response functions (IRFs) if the VAR is stable (Baum, 2013). Further tests include the Wald test, to test for Granger causality between the independent and dependent variables, and variance decomposition, which forecasts the percentage each independent variable contributes to movements in the dependent variable. For the cointegration, VECM, and VAR tests this paper uses the AIC optimal lag length criterion to determine the number of lags. Furthermore, although the VECM, VAR, and variance decomposition tests produce multiple vectors for each dependent and independent variable this paper will only focus on the vector where the stock market is the dependent variable, consistent with the aim of this dissertation.

4.3 Control variable specification

To assign the control variables Z_t this paper draws on the strengths of previous literature (Davis and Li, 2003) and uses the dividend growth model (Gordon, 1962). The model indicates that stock prices today are affected by the level and growth of dividends in the future (Bodie *et al*., 2014).

$$V_t = \frac{D_{t+1}}{k-g} \quad (4)$$

The dividend growth model is shown in equation (4) where V_t is the value of a stock in period t, D_t is the dividend paid in period t, g is the growth rate of dividends and k is the real long term interest rate plus the risk premium (Davis and Li, 2003). The dividend growth model in equation (4) assumes a perpetual and constant growth rate. The variables used to represent this model are described in Section 4.4.

4.4 Variable selection

In this sub-Section each variable is presented, examining their relevance and how they have been calculated. A full list of data sources is available in Table A1.

The dependent variable RTN is the real log return of ASX stock prices, calculated as $ln(\frac{P_t}{P_{t-1}})$, where ln is the natural log and P_t is the stock price in period t. The ASX is chosen as it combines the FTSE100, FTSE250 and the FTSE SmallCap indices providing an overall representation of the UK stock market. This paper uses RTN because it allows comparability with previous UK studies by Poterba (2001) and Davis and Li (2003), which investigate stock market returns. However, this paper uses the variable $STCK$, which is the real stock market price of the ASX, as the dependent variable in the VECM test. This is because stationarity tests in Section 5 show RTN is I(0) and would therefore produce unreliable results if used in cointegration and VECM tests alongside I(1) variables, because the variables have to be integrated to the same order in these tests (Adkins, 2013a). $STCK$ on the other hand is I(1) and can therefore be reliably used. To ensure comparability with previous studies and to maintain the focus on the returns of the stock market, this paper constructs the VAR using RTN as the dependent variable. This is because VAR allows I(0) and I(1) variables to be tested simultaneously (Toda and Yamamoto, 1995).

$POP40$ is the percentage of the total population in the UK aged 40-64. $POP65$ is the percentage of the total population in the UK aged 65+. These demographic variables are calculated using mid-year data (ONS, 2015a) and are therefore not a perfect representation of January to December yearly data. However, the data still takes into account the important year-on-year changes and is the most recent source of population data for the UK. Older year-end sources, such as Population Trends (OPCS, 1994), would restrict the sample period.

$$Z_t = G_{t-1} + DY_{t-1} + IR_t + VOL_{t-1} + GAP_{t-1} + d2007 \quad (5)$$

Equation (5) shows the control variables in this study derived from the dividend growth model (Gordon, 1962). The variable G is the trend growth rate of GDP, calculated using the Hodrick-Prescott filter with a smoothing factor of 100 on the log change of real GDP. G provides a representation for dividend growth (Brunetti and Torricelli, 2010). The GDP data used to calculate G is chained volume data and therefore importantly takes into account the effects of inflation. In line with the dividend growth model a rise in G is expected to increase the ASX.

DY is the dividend yield, for which a proxy has been created. This is because data on the ASX dividend yield is only available from 1997, which this paper argues is too short of a time period to produce reliable results for a study on long-term changing demographic and stock market movements. The proxy is calculated using a ratio between the 2.5% consol yield in the UK and the ASX dividend yield. This follows the research suggesting market forces bring the ratio of these variables together into equilibrium over time (Clare *et al*., 1994).

$$\frac{2.5\%\ consol\ yield}{DY} = 1.5 \quad (6)$$

Equation (6) presents the proxy. The median of 1.5 is calculated using the dividend yield data available from 1997-2014 alongside the 2.5% consol yield data. The median is then applied to the 2.5% consol yield from 1963, solving for DY. The median is taken instead of the mean to reduce the impact of any large outliers. An increase in DY is expected to increase V in equation (4) and thus result in a positive increase in the ASX.

IR is the real 10-year UK bond interest rate and VOL is a measure of volatility, calculated through the standard deviation of log changes in ASX stock prices. These variables represent k in the dividend growth model (Davis and Li, 2003) with VOL being used as a proxy for the equity premium (Brunetti and Torricelli, 2010). An increase in k will decrease V in equation (4) *ceteris paribus*; therefore, an increase in IR and VOL is expected to decrease the ASX.

GAP is the difference between the real GDP growth rate and G. It does not follow from the dividend discount model but has been included because economic theory suggests cyclical movements in GDP may affect stock prices (Brunetti and Torricelli, 2010). An increase in GAP is expected to increase the ASX, as higher than expected GDP growth should increase stock prices.

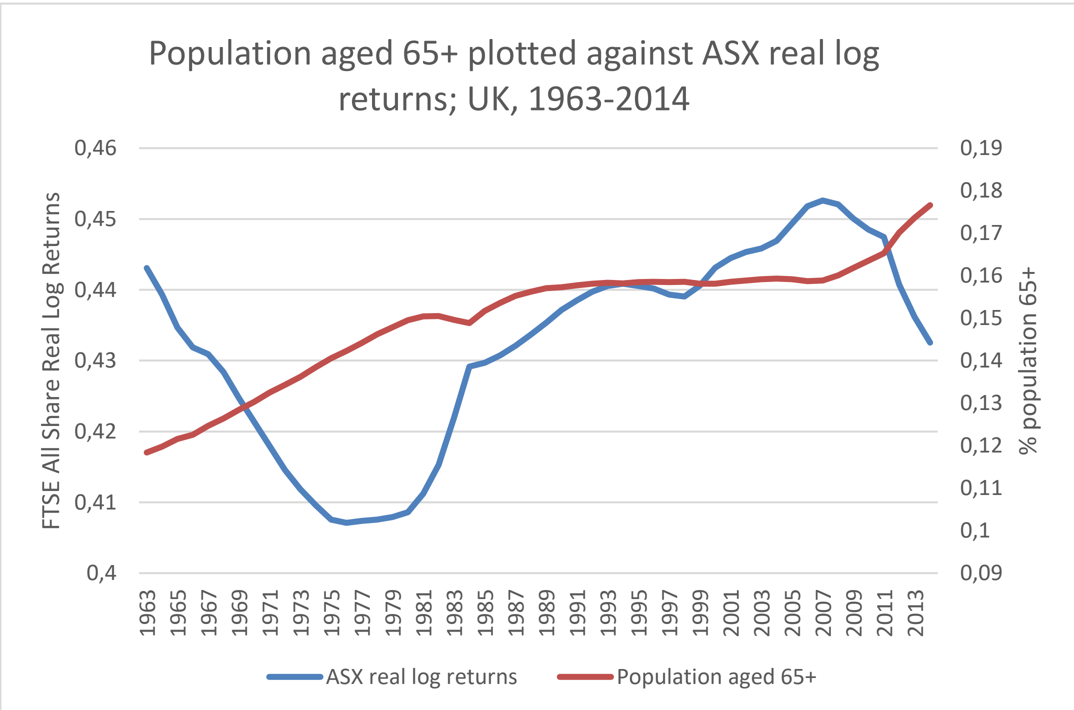
A dummy variable $d2007$ is also added for an outlier in 2007, which was discovered by reviewing the error residuals of the dependent variable RTN. Literature suggests it is caused by the financial crisis starting August 2007 (Taylor, 2009). The dummy helps reduce serial correlation in the VECM and VAR tests and should therefore improve the robustness of the study.

G, GAP, DY and VOL are lagged because the data for these variables is released with a time delay. For example, GDP data is released one month after the quarter it has occurred (ONS, 2016). Therefore, although these variables may occur in time period 1, market participants do not act upon them until time period 2 (Brunetti and Torricelli, 2010). This paper also takes the log of all variables except for IR and GAP, due to negative values, which allows elasticity interpretation.

4.5 Sample period analysis

The sample period was initially constrained by a lack of ASX dividend yield data, however, the use of the DY proxy has extended the period studied by thirty-four years from 1997-2014 to 1963-2014, which allows a more in-depth study to be conducted. Had data been readily available for the ASX and demographics this paper would have further extended the study to 1940, allowing greater analysis of the post-war baby boom period. Each variable is taken yearly and thus yields 51 observations for each model. By studying the time period 1963-2014 this paper extends previous literature that ends in the early 2000's (Davis and Li, 2003; Poterba, 2001).

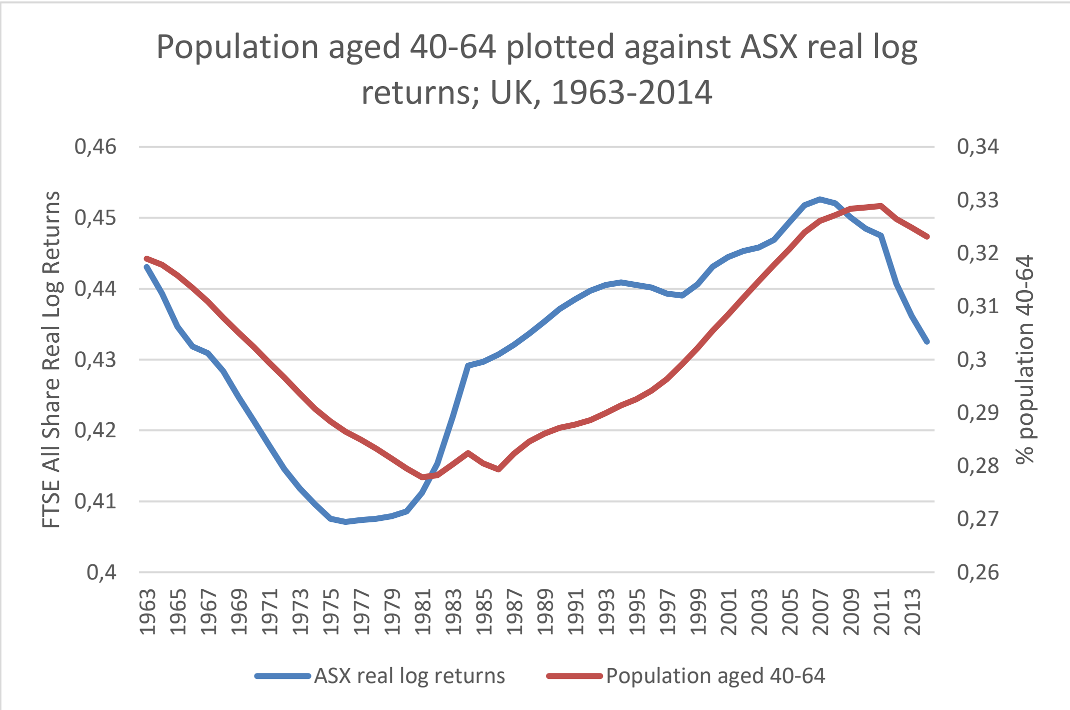
Figure 2: Population aged 40-64 plotted against ASX real log returns; UK, 1963-2014



Source(s): Data for ASX from Dimsdale *et al*. (2010), population from ONS (2015a)

Figure 2 shows 40-64 and ASX returns over the sample period. The two variables follow a positively correlated pattern, both falling from 1963 to the late 1970s and then rising in the 1980s towards 2007, where they start peaking. From 2010 to 2014, however, the 40-64 cohort declines, but the ASX returns fall to an even greater degree. This could be attributable to the financial crisis of 2007, which caused stock markets to generate lower returns (Goodhart, 2008). However, a more in-depth investigation into UK demographics in Figure 3 finds that in this period the 65+ cohort rises steeply, which this paper argues may also be contributing to the steep reduction in stock returns.

Figure 3: Population aged 65+, plotted against ASX real log returns; UK, 1963-2014



Source(s): Data for ASX from Dimsdale *et al*. (2010), population from ONS (2015a).

Figure 3 shows the 65+ cohort and ASX returns from 1963-2014. In this figure the correlation between the variables is not as clear. Economic theory suggests a negative correlation; however, the relationship appears to be positive from 1975 to 1990. Furthermore, there is arguably no correlation from 1990 to 2007, where 65+ remains constant, but returns increase. Possible reasons for this may be the 65+ cohort not yet reaching a large enough size to have an impact on the stock market (see Section 2), or international capital flows, which could be diminishing the relationship between population ageing and the stock market (see Section 3). A more in-depth econometric study is undertaken in the next Section to determine if this is the case.

5. Empirical Results

Following the method in Section 4.2 this paper now presents the econometric results.

5.1 Stationarity

Where stationarity is present the variable should demonstrate covariance that does not vary over time and a mean and variance that are constant (Enders, 1995). This is important because if a variable does not meet these criteria, and is non-stationary, then simple linear regression will lead to spurious regression and invalidity (Cohn and Kolluri, 2003; Lancheros, 2016). This paper uses ADF and PP stationarity tests, which indicate stationarity if the null hypothesis of a unit root is rejected (Dickey and Fuller, 1979; Phillips and Perron, 1988). To identify the number of lags required for the stationarity tests this paper uses the Breusch-Godfrey test for serial correlation (Table A2). Due to the presence of no serial correlation the test indicates zero lags in the ADF and PP test.

Table 2: Stationarity tests

	STCK	RTN	G	GAP	DY	IR	VOL	GDP
At Level								
ADF	-2.254	-7.825*	-0.754	-5.520*	-2.559	-4.521*	-4.790*	-1.836
PP	-2.104	-7.992*	-1.544	-5.367*	-2.566	-4.583*	-4.813*	-2.262
First Difference								
ADF	-8.288*	-	-0.744	-	-4.845*	-	-	-5.015*
PP	-8.674*	-	-2.002	-	-4.703*	-	-	-4.931*
Second Difference								
ADF	-	-	-1.974**	-	-	-	-	-
PP	-	-	-2.475	-	-	-	-	-

Source(s): Own calculations.
Notes: * denotes significance at the 99% confidence level.
** denotes significance at the 95% confidence level.

Table 2 presents the stationarity tests. RTN, GAP, IR and VOL are integrated to order 0 and therefore stationary at level. GDP, DY and $STCK$ are stationary in their first differences and G is found to be stationary in its second difference. The demographic variables are not tested for stationarity, as they do not follow a random walk* (Jamal and Quayes, 2015).

However, this paper questions the reliability of the stationarity tests. Kwiatkowski *et al*. (1992) argue that the ADF and PP tests often fail to reject the presence of a unit root and Nelson and Plosser (1982) find in a study of fourteen time-series models that only one series rejects the null hypothesis of non-stationarity, thus questioning the effectiveness of the tests. Given the above, this paper decides to construct the cointegration tests in Section 5.2 under the assumption that G is I(1). This is important, because for cointegration tests to be constructed all the variables have to be integrated to the same order. Thus, by treating G as I(1), and not I(2), it can be included in the study. The robustness of this assumption is tested through a proxy variable GDP, which is the UK chained volume measure of GDP based to 1963. GDP is I(1) in the stationarity tests and is substituted for G in separate robustness cointegration tests, which can be found in Tables A3 and A4. As a whole the results suggest using G as I(1) is justified, with only one proxy cointegration test showing insignificance (Table A3).

5.2 Cointegration

The stationarity tests show that not all variables are integrated to the same order, therefore this paper only constructs cointegration tests for the variables $STCK$, G, DY and the demographic variables, which are integrated to the same level I(1). If these variables' error terms are jointly stationary then they follow a common stochastic trend (Krätzig and Lütkepohl, 2004) and are therefore co-integrated (Adkins, 2013b). If cointegration occurs then VECM and VAR tests can be constructed.

Table 3: Engle-Granger cointegration

	Model I	Model II
Z(t)	-3.187**	-3.504**

Source(s): Own calculations.
Notes: * denotes significance at the 99% confidence level.
** denotes significance at the 95% confidence level.

This paper first uses the Engle-Granger cointegration test, which tests the error terms for stationarity using an ADF stationarity test (Sjö, 2009). The results are shown in Table 3, where the null hypothesis is that the error terms are non-stationary. They indicate cointegration in both models. The GDP robustness test in Table A3 shows cointegration in model I but not model II.

* ADF constructed out of interest found that $POP40$ and $POP65$ are I(1).

The Johansen test is also constructed and has the added benefit of being able to identify multiple cointegrating relationships (StataCorp, 2014). Table 4 shows the results. When the trace statistic is greater than the critical value, the null hypothesis of no cointegration among variables is rejected (StataCorp, 2014). Both models have one cointegrating rank, suggesting a relationship exists between the variables. The GDP robustness test in Table A4 also shows cointegration in both models.

Table 4: Johansen cointegration, Model I

Maximum Rank	Parameters	LL	Eigenvalue	Trace statistic	5% critical value
0	52	457.189	-	66.203	47.21
1	59	479.750	0.609	21.080*	29.68
2	64	487.447	0.274	5.686	15.41
Model II					
0	68	450.117	-	52.128	47.21
1	75	466.644	0.505	19.084*	29.68
2	80	473.386	0.249	5.600	15.41

Source(s): Own calculations.
Notes: Three and four lags respectively, determined by AIC optimal lag length criterion.
*denotes number of cointegration ranks.

5.3 Model I

5.3.1 Vector error correction model

Following the cointegration tests the VECM is constructed for model I to investigate whether a long-run relationship exists between the cointegrating variables G, DY and the demographic variables, with the variable $STCK$. The stationary variables cannot be included endogenously because they are integrated to a different level to the non-stationary variables. However, they are included exogenously in order to still provide an understanding of their relationship with the stock market. The dummy variable is also included to account for the 2007 outlier. Using the Johansen result of one cointegrating rank (see Table 4), the VECM for model I is presented in Table 5.

The $STCK$ vector for the VECM is presented in Table 5. The Lagrange-Multiplier in Table A5 shows that the model does not suffer from serial correlation and is consequently well fitted at these lags. Table 5 shows the error correction term is statistically significant and negative at -0.042. This indicates a long-run equilibrating relationship between the variables. The positive coefficients of +8.082 and +11.130 for $POP40$ are consistent with economic literature, suggesting an increase in this age group increases stock market prices. However, the lagged values are not statistically significant, therefore suggesting the long-run equilibrating relationship is weak.

Table 5: Vector-error correction model

$$\Delta STCK_t = cons + \beta_1.\Delta STCK_{t-1} + \beta_2.\Delta STCK_{t-2} + \beta_3.\Delta POP40_{t-1} + \beta_4.\Delta POP40_{t-2} + \beta_5.\Delta G_{t-1} + \beta_6.\Delta G_{t-2} + \beta_7.\Delta DY_{t-1} + \beta_8.\Delta DY_{t-2} + \beta_9.d2007 + \beta_{10}.VOL_{t-1} + \beta_{11}.GAP_{t-1} + \beta_{12}.IR_t + ECT$$

β_1	β_2	β_3	β_4	β_5
-0.338**	-0.014	8.082	11.130	1.844
(0.149)	(0.175)	(9.130)	(9.032)	(1.416)
β_6	β_7	β_8	β_9	β_{10}
1.664	-0.222	0.321	0.117	-0.016
(1.591)	(0.500)	(0.471)	(0.222)	(0.031)
β_{11}	β_{12}	ECT	$cons$	R^2
-6.172	-1.460	-0.042**	0.0124	0.564
(1.912)	(1.159)	(0.016)	(0.099)	

Source(s): Own calculations.
Notes: Three lags determined by AIC optimal lag length criterion.
ECT is error correction term. Δ denotes the first difference.
Standard errors in parentheses.
**denotes number of cointegration ranks.

5.3.2 Vector auto regression

The VAR is constructed with three lags, as per the AIC optimal lag length criterion, and the Lagrange-Multiplier test in Table A6 displays no serial correlation, which indicates the model is well fitted. Wald tests in Table A7 show that all variables are jointly significant indicating a Granger causal short-run relationship between $POP40$ and ASX returns, and that the variables are justifiably included in the model. The stability test in Table A8 shows no eigenvalues greater than 1, indicating the VAR is stable (StataCorp, 2014). Therefore, an IRF can be constructed in Figure 4.

Figure 4 demonstrates that an impulse to the $POP40$ variable will initially have a positive impact on ASX returns, consistent with the economic literature. However, the impact begins to fall negative after three steps, suggesting the market may have over reacted. Upon further investigation this paper argues this may be due to the life cycle risk aversion hypothesis (Bakshi and Chen, 1994), which suggests that individuals develop stronger preferences for bonds over stocks, as they get older. In the case of Figure 4 the 40-64 cohort could be starting to replace their stocks for less risky assets in later steps, causing the returns to decline.

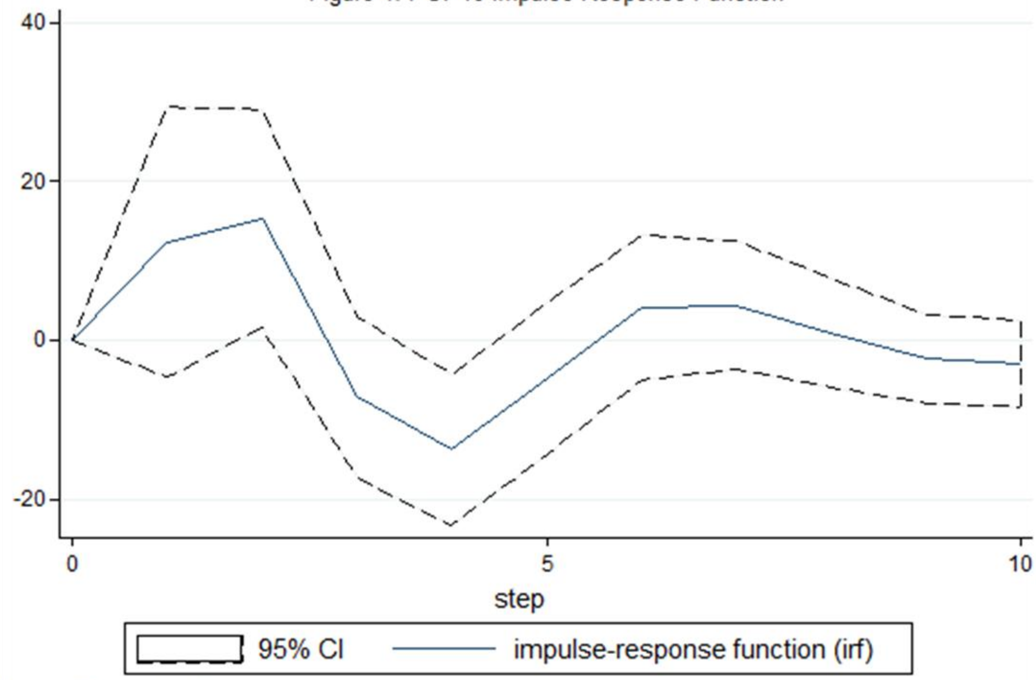


Figure 4. POP40 Impulse Response Function

Source: Own calculations

5.3.3 Variance decomposition

The stability test in Section 5.3.2 is stable (see Table A8), which indicates that a variance decomposition model can be constructed.

Table 6: Variance-decomposition model

Step	RTN	POP40	G	DY
1	1	0	0	0
2	0.949	0.003	0.002	0.043
3	0.885	0.011	0.009	0.093
4	0.866	0.013	0.018	0.101
5	0.825	0.021	0.025	0.127
10	0.804	0.025	0.035	0.135

Source(s): Own calculations.
Notes: One step represents one year.

Table 6 shows the results of the test, with RTN as the dependent variable and the I(1) non-stationary variables as the independent variables. The stationary I(0) variables are exogenous in this test, as their inclusion causes instability in the model. The variance decomposition forecasts the contribution each variable has in causing changes in the dependent variable. Table 6 shows that in the short-run returns to the ASX are predominantly explained by previous returns, with a 94.9 per cent value of RTN in year

2, decreasing to 80.4 per cent in year 10. $POP40$ has a small impact on returns that grows over time from 0.3 per cent to 2.5 per cent over the ten year forecast. This indicates a weak long-run relationship, and arguably little short-run impact. DY's higher percentage contribution than $POP40$ indicates the improved ability of the dividend growth model (Gordon, 1962) in explaining changes in stock prices.

5.3.4 Summary of results

Model I's results, although weak, are consistent with the economic literature in Section 3.1, which suggests a rise in the 40-64 cohort leads to a greater demand for stocks and thus higher returns. Furthermore the results appear to be in line with the predictions made in Section 4.5, where the sample period analysis indicates a positive correlation. However, the results differ from Poterba (2001) and Davis and Li (2003), who do not find a statistically significant relationship for the 40-64 cohort in the UK. This may be due to the extension of the sample period in this study compared to the previous literature. Additionally it is argued that this paper has produced a enhanced explanatory model by using the dividend growth model to define the control variables, as opposed to Poterba (2001) who only uses GDP and interest rates.

5.4 Model II

5.4.1 Vector error correction model

The VECM for model II is constructed using the Johansen results of one cointegrating rank (see Table 4). The results are shown in Table 7.

As before the focus is on the $STCK$ vector, consistent with the topic of this paper. The Lagrange-Multiplier in Table A5 shows no serial correlation demonstrating a well-fitted model, however Table 7 shows the error correction term is -0.000 and insignificant. This indicates that there is no long-run equilibrating relationship over the sample period, as a negative and significant error correction term is required to conclude a long-run relationship (Baum, 2013). The use of four lags and a lack of significance in any of the variables further suggests a relationship does not exist in this model. The r-squared value of 0.505 is lower than model I's 0.564, which is expected considering the lack of a long-run relationship.

Table 7: Vector error correction model

$$\Delta STCK_t = cons + \beta_1.\Delta STCK_{t-1} + \beta_2.\Delta STCK_{t-2} + \beta_3.\Delta STCK_{t-3} + \beta_4.\Delta POP65_{t-1} + \beta_5.\Delta POP65_{t-2} + \beta_6.\Delta POP65_{t-3} + \beta_7.\Delta G_{t-1} + \beta_8.\Delta G_{t-2} + \beta_9.G_{t-3} + \beta_{10}.DY_{t-1} + \beta_{11}.DY_{t-2} + \beta_{12}.DY_{t-3} + \beta_{13}.d2007 + \beta_{14}.VOL_{t-1} + \beta_{15}.GAP_{t-1} + \beta_{16}.IR + ECT$$

β_1	β_2	β_3	β_4	β_5
-0.178	-0.024	0.046	4.416	-11.077
(0.297)	(0.280)	(0.234)	(7.771)	(8.732)
β_6	β_7	β_8	β_9	β_{10}
-0.567	5.144	-5.832	2.889	0.143
(9.118)	(4.167)	(7.762)	(4.372)	(0.545)
β_{11}	β_{12}	β_{13}	β_{14}	β_{15}
0.809	0.369	0.150	-0.032	-5.404
(0.555)	(0.497)	(0.265)	(0.040)	(2.320)
β_{16}	ECT	$cons$	R^2	
-2.240	-0.000	0.051	0.505	
(1.591)	(0.228)	(0.265)		

Source(s): Own calculations.
Notes: Four lags determined by AIC optimal lag length criterion.
ECT is error correction term.
Standard errors in parentheses.
**denotes significance at the 95% confidence level.

5.4.2 Vector auto regression

The VAR is constructed with three lags, as per the AIC optimal lag length criterion. Furthermore, the Lagrange-Multiplier test in Table A6 displays no serial correlation, indicating the model is well fitted. However, all the variables are jointly insignificant in the Wald test (Table A7), suggesting their inclusion in the model is unjustified and a Granger causal short-term relationship does not exist. Furthermore, an IRF cannot be reliably constructed, because the stability test does not pass (Baum, 2013) (see Table A8).

5.4.3 Variance decomposition

Similar to the IRF, the variance decomposition cannot be constructed because at least one eigenvalue is greater than 1 in the stability test (Baum, 2013) (see Table A8). If a variance decomposition model had been constructed, regardless of the stability test, the results would have been unreliable, reducing the robustness of this study.

5.4.4 Summary of results

Model II displays a lack of statistically significant results and therefore it can be argued that population ageing does not have implications for the stock market in the UK. This paper argues these results may be explained by international capital flows, which are not accounted for in this study due to the assumption of a closed economy. As mentioned in Section 3, in an open economy, younger individuals from growing emerging markets may purchase the oversupply of stocks from ageing countries, diminishing the theoretical relationship between the 65+ cohort and the stock market. This is particularly likely in the UK where domestic stock ownership is relatively low at 46.2 per cent (ONS, 2015c), compared to the US at 90 per cent (French and Poterba, 1991). This may explain why studies on the US produce statistically significant results (Davis and Li, 2003), because they may be less affected by international capital flows.

Analysis of population ageing in Section 2 may also explain the insignificant results in this model, where it is argued the 65+ cohort has yet to reach a large enough size to affect the stock market. This could be why a statistically significant relationship is found in Brunetti and Torricelli's (2010) Italian model and not in these results, as population ageing is more pronounced in Italy (see Section 2.1).

5.5 Limitations

Following from the econometric results this paper finds a number of limitations to the study. For example, the DY proxy has been constructed from a credible article in the Economic Journal (Clare *et al*., 1994), however it is still possible that it is an inaccurate representation of the ASX's actual dividend yield, which therefore may reduce the accuracy of this paper's results. Furthermore, the assumption that G is I(1), when the stationarity tests indicate I(2), may affect the reliability of the cointegration results. Although the GDP variable proxy for G found similar results for cointegration in general, the Engle-Granger test for model II in Table A3 produced no cointegration, suggesting there may be flaws in using G as I(1).

International capital flows may also limit the effectiveness of the study, it was found in Section 3 that 53.8 per cent of shares in the UK are owned by foreigners (ONS, 2015c). Therefore, if an imbalance between the 65+ and 40-64 cohort occurs, retirees may sell their assets to younger cohorts in foreign emerging economies (Poterba, 2004). This would mitigate the expected fall in the stock market and is not fully accounted for in the study, which assumes a closed economy.

Lastly this study was limited by the word count. Additional econometric tests and models, such as an ARDL test and a demographic model investigating the ratio of 65+ to 40-64, could have been constructed. This would have offered a more comprehensive set of conclusions, improving the reliability and robustness of the study.

5.6 Future developments

Reviewing the limitations there are a number of developments that could improve the robustness of this study. Firstly, paying for access to more comprehensive databases, such as the Global Financial Database, may reduce the need to use a dividend proxy, which could improve the accuracy of the results. Furthermore, this paper could construct a panel data econometric test, which would take into consideration the open economy by reviewing multiple countries and stock market simultaneously. This will provide an overview of how capital flows between the countries may affect the relationship between demographics and stock market. Lastly a higher word count could provide the opportunity to construct an ARDL test as well as additional demographic models, such as the ratio of 65+ to 40-65, which would offer alternative results to the VECM and VAR, benefiting the reliability and robustness of the study.

6. Conclusion

In order to achieve the aim of investigating the implications of population ageing on the stock market in the UK, this paper first found in Section 2 that population ageing is in fact occurring, and that low fertility rates and increasing life expectancy suggest it will continue. In Section 3 this paper examined the economic literature, such as the LCH, which suggested population ageing should affect the stock market. Furthermore, in Section 3.2, by reviewing previous econometric studies, this paper found it could add value by extending the sample period to 2014, and by using a more comprehensive set of explanatory variables through Gordon's (1962) dividend growth model.

In Section 4 this paper outlined the two models, 40-64 and 65+, and constructed a time series econometric study to examine if a relationship with the stock market exists. This paper used a cointegration, VECM and VAR approach because non-stationarity was found in a number of variables, which could cause spurious regression in simple linear regression (Lancheros, 2016). When plotting the demographic models against ASX returns in Section 4.5 this paper argued the 40-64 model has a positive correlation, however the 65+ model appeared uncorrelated. The econometric study confirmed these findings, demonstrating a weak statistically significant relationship between 40-64 and the ASX, but insignificance in the 65+ model, suggesting population ageing does not have implications for the stock market in the UK.

This paper argued that the reason the population ageing 65+ model shows insignificance is likely to be a result of international capital flows preventing stocks from becoming oversupplied in the UK stock market, and that this is overlooked in the study due to the assumption of a closed economy. It was argued that international capital flows are particularly likely to affect the UK because of relatively low domestic stock ownership, at 46.2 per cent (ONS, 2015c). It was also suggested the insignificants results may be due to the 65+ cohort not yet reaching a large enough size to affect the ASX, following a review of UK population ageing in Section 2 compared with Italy.

This paper found a number of limitations. The use of a dividend proxy may reduce the accuracy of the study, and the assumption of G being I(1) could reduce the reliability of the results, even though robustness tests show general justification for the assumption. It was further found that international capital flows were not fully accounted for due to the assumption of a closed economy.

Finally, this paper discussed future developments, such as paying for access to more comprehensive databases, which may contain the actual dividend yield, and constructing a panel data econometric study, which would take into account international capital flows by investigating multiple countries and stock markets simultaneously. This paper lastly suggested that a higher word count would allow for additional econometric tests and models to be constructed, such as the ARDL test and the ratio of 65+ to 40-64, which would further improve the robustness of the study.

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Appendix

Table A1: Variable descriptions

Variable	Description	Frequency	Source
RTN	Log change in real ASX prices.	Yearly	Dimsdale *et al.* (2010)
$STCK$	Real ASX prices.	Yearly	Dimsdale *et al.* (2010)
$POP40$	Percentage of total population aged 40-64.	Yearly	ONS (2015a)
$POP65$	Percentage of total population aged 65+	Yearly	ONS (2015a)
G_{t-1}	GDP trend growth rate.	Yearly	ONS (2015d)
GAP_{t-1}	Difference between GDP growth rate and g.	Yearly	ONS (2015d)
IR_t	Real long-term interest rate.	Yearly	OECD (2014)
VOL_{t-1}	Share price volatility.	Yearly	Dimsdale *et al.* (2010)
DY_{t-1}	Dividend yield. Proxy from 1963-2014.	Yearly	DY data from Bloomberg (2016). Consol yield from UK DMO (2015).
GDP_{t-1}	Gross domestic product. Chained Volume Measure.	Yearly	ONS (2015d)

Table A2: Beusch-Godfrey Model

Lags	Chi2	Degrees of freedom	Prob > Chi2
1	1.282	1	0.258
2	3.646	2	0.162
3	3.885	3	0.274
Model II			
1	0.890	1	0.345
2	2.965	2	0.227
3	2.983	3	0.394

Source(s): Own calculations.
Notes: Prob>2 chi 2 greater than 0.05 does not reject null hypothesis of no serial correlation at 95% confidence interval.

Table A3: GDP Engle-Granger robustness

	Model I	Model II
Z(t)	-4.014*	-2.421

Source(s): Own calculations.
Notes: * denotes significance at 99% confidence level.
** denotes significance at the 95% confidence level.

Table A4: GDP Johansen cointegration robustness

Model I

Maximum Rank	Parameters	LL	Eigenvalue	Trace statistic	5% critical value
0	68	493.352	-	149.174	47.21
1	75	549.645	0.90887	41.681*	29.68
2	80	557.336	0.27911	14.936	15.41
Model II					
0	36	460.173	-	107.860	47.21
1	43	501.054	0.811	26.098*	29.68
2	48	509.336	0.286	9.534	15.41

Source(s): Own calculations.
Notes: Four and two lags respectively, determined by AIC optimal lag length criterion.
Indices number of cointegration ranks.

Table A5: Lagrange-Multiplier vector error correction

Model I

Lag	Chi2	Prob>chi2
1	22.795	0.119
2	13.744	0.617
3	16.825	0.397
Model II		
1	13.307	0.650
2	15.483	0.489
3	13.645	0.625
4	25.684	0.058

Source(s): Own calculations.
Notes: Sixteen degree of freedom.
Prob>chi2 greater than 0.05 does not reject null hypothesis of no serial correlation at 95% confidence interval.

Table A6: Lagrange-Multiplier vector autoregression

Model I

Lag	Chi2	Prob>chi2
1	11.610	0.770
2	15.404	0.495
3	12.546	0.705
Model II		
1	14.092	0.591
2	13.437	0.640
3	7.062	0.972

Source(s): Own calculations.
Notes: Sixteen degree of freedom.
Prob>chi2 greater than 0.05 does not reject null hypothesis of no serial correlation at 95% confidence interval.

Table A7: Wald Granger causality

Model I

Equation	Variable	Chi2	Prob>chi2
RTN	$POP40$	12.085	0.007
	G	16.161	0.001
	DY	13.145	0.004
	ALL	22.758	0.007
Model II			
RTN	$POP65$	3.910	0.271
	G	7.163	0.067
	DY	4.982	0.173
	ALL	13.131	0.157

Source(s): Own calculations.
Notes: Prob>chi2 greater than 0.05 does not reject null hypothesis of no serial correlation at 95% confidence interval.

Table A8: Eigenvalue stability

Model I	Model II
Eigenvalue	Eigenvalue
0.999	0.914 + 0.481*i*
0.895 + 0.360*i*	0.914 – 0.481*i*
0.895 - 0.360*i*	1.020
0.937 + 0.110*i*	0.961 + 0.117*i*
0.937 - 0.110*i*	0.961 - 0.117*i*
0.405 + 0.695*i*	0.339 + 0.795*i*
0.405 - 0.695*i*	0.339 - 0.795*i*
-0.611	0.117 + 0.845*i*
-0.106 + 0.584*i*	0.117 - 0.845*i*
-0.106 - 0.584*i*	-0.165 + 0.751*i*
0.124 + 0.392*i*	-0.165 - 0.751*i*
0.124 - 0.392*i*	0.714 + 0.247*i*

Source(s): Own calculations.
Notes: The null of a stable VAR is rejected if at least one eigenvalue takes the value of 1 or above.