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Abstract

The effect of the aging baby-boom-cohort on asset values is extensively studied. While that effect varies by country, there are likely to be commonalities. Thus, research on a relatively small advanced open economy like New Zealand can provide insight into the general effect. In this study monthly data from 1991-2017 is used to examine how aging population in New Zealand affects its stock market considering key demographic and non-demographic macroeconomic variables and a new focus on fast-and-slow-moving institutional change. The results suggest that the net effect of an aging population on stock markets is insignificant. However, real GDP and foreign portfolio investment (FPI) show a positive relationship with the stock market. The findings reveal that FPI can mitigate possible negative effects from aging in an open economy. Moreover, the policy implications of the study suggest that international-factor mobility, skilled-migration policies, and technology-based productivity growth can boost stock markets.

JEL Classification: G23; J10; F49

Keywords: Stock-prices; Baby-boomers; Demographics; Macroeconomic variables; New Zealand; time series

Highlights

- Effects of New Zealand's aging population on stock prices are explored.
- A range of macroeconomic factors are considered (ignored in many studies).
- Aging population does not appear to have a net effect on stock markets.
- Real GDP and foreign-portfolio-investment positively affect stock prices.
- Policy recommendations include increasing productivity and skilled-migration.

Does an aging population influence stock markets? Evidence from New Zealand

Introduction

This paper empirically investigates the relationship between stock-market dynamics and changing baby-boomer demography focusing on macroeconomic factors in New Zealand (NZ) using monthly data from 1991-2017.An aging population is a major policy concern for the developed countries (DCs), leading to increasing worry over maintaining sustainable socio-economic balances (Cobb-Clark and Stillman, 2009; Poterba, 2014). United Nations Populations Projections (2011) suggest that over the next 40 years the old age dependency ratio (old-to-working-age-population ratio) will almost be double, in advanced economies. Statistics New Zealand (2016)[1] echoes the same, stating that the rise in older segment of the population is much faster than the increase in the number of children. Aging populations in developed countries (DC) causes governments to encourage workers to save more during their working life so as to complement rising government pension costs. Contrary to the Keynesian concept of thrift being disruptive (i.e. savings reduce consumption, offsetting expansion in investment), in the post-Keynesian era, national savings are seen as a source of capital and enhance labour productivity and growth (Modigliani, 1986). There is a substantial literature using lifecycle to explain individual thrift, savings, and consumption behaviour. Life cycle hypothesis (LCH) highlights the income-to-wealth relationship *vis-à-vis* the consumption-investment trade-off across the life-cycle pattern of earnings (Modigliani and Brumberg, 1954; Ando and Modigliani, 1963; Modigliani, 1986). LCH implies that people in their high-income-earnings age tend to invest in more risky assets and at, or near, retirement age they tend to

[1] See for details https://www.stats.govt.nz/topics/population.

shift from risky to less risky assets. Many researchers focus on the risk of a meltdown of higher-risk asset prices (e.g. stock markets) due to the expected aging of the population (Mankiw and Weil, 1989; Poterba, 2001; Poterba, 2004; Huynh *et al.*, 2006; Poterba, 2014).

Understanding the channels through which an aging population can affect asset markets has become vital for policy makers. Over four decades, the research has contributed to this debate. The effect of aging baby-boomers can vary by country and there are likely to be considerable commonalities. Thus, researching the effect of aging cohort on asset values in a relatively small advanced open economy like NZ can provide useful general insight for the business sector and policy makers. This study focuses on how NZ's aging population affects its stock market and considers the channels through which such effects (e.g. suggested by LCH) and counter effects may flow.

The channels described in LCH of lifecycle patterns and demographic swings combined with the effect of risk-averse shifts in an aging population on capital markets, have been a popular research focus over the past few decades (Holtz-Eakin *et al.*, 1993; Bakshi and Chen, 1994; Brooks, 1999; Abel, 2001; Huynh *et al.*, 2006). Poterba (2004) asserts that an aging population can influence the stock market by shifting portfolio decisions from a longer-to a shorter-term focus, as post-retirees start drawing down (rather than adding to) their wealth portfolio. Huynh *et al.* (2006) found that the relative size of the 40-64 age cohort and Australian superannuation funds have significant effects on share prices. The transmission channels of how aging population affects stock market negatively suggested in the literature can be discussed in the following three ways: (1) LCH, demand for and supply of financial assets channel: higher proportion of aging population relative to working age population $\rightarrow$ more people move their investments from high risky long-term investment such as stocks to less risky short-term investment such as government bonds $\rightarrow$ the demand for risky assets decreases but the supply of risky assets increases due to more people selling their high risky assets $\rightarrow$ stock prices decrease; (2) LCH, demand for and supply of goods/service channel: higher proportion of aging population relative to working age population → less demand for durable and some consumable goods but higher demand for healthcare services → consumption and investment for specific sectors may increase at the cost of the other sectors → the net impact of aging population on aggregate stock prices depend on the constitutes of the stock markets; and (3) LCH, demand for and supply of labour force channel: higher proportion of aging population relative to working age population → less active working age population → decrease in labour force in production→less output → less profitability → stock prices decrease (Abel, 2001; Huynh *et al.*, 2006; Werblow *et al.*, 2007; Gordon, 2016).

However, there may be some limitations of LCH in an open economy and that can explain why aging population does not necessarily negatively influence stock prices. Firstly, following international division of labour and international industrial specialisation theories, an open economy, especially a developed country, can be specialised in some high-value-added (such as knowledge-intensive and capital-intensive) sectors, which are more inclined to the quality of skilled working population rather than the volume of total working-age population. Secondly, it ignores the demand for goods/services and supply of labour forces/capital from other countries. Following international trade theories, the movements of goods/services, labour and capital may defer or even offset the negative impact of aging population on any small open economy like NZ (Higgins, 1998; Helliwell, 2004). Third, it ignores the substitute of capital (technology) and labour force, for example, robotics can substitute labour forces. Given that robotics could generate economies of scale effect by adopting robot technology replacing labours may feeble the negative effect of aging population (Acemoglu and Restrepo, 2017).

While the relationship between the stock market and non-demographic macroeconomic variables are well researched for large-open DCs (Fama, 1990; Chen, 1991), the findings are often contentious in terms of policy formation. Further, there is a significant knowledge gap on the effect of demographic and macroeconomic variables on growing stock markets in small-open DCs. Importantly, rapid globalization has made small-open DCs more vulnerable to external shocks, as well as reducing boundaries increases the accessibility to new markets encouraging further empirical investigation on relatively untapped markets. Hence, this study examines the relationship between stock prices and changing population structure alone and also together with macroeconomic factors using NZ data to examine whether the Ando and Modigliani (1963) seminal study 'Life-Cycle Hypothesis' (LCH) is binding in small open economies. This study advances the literature in several ways:

i) It uses the relatively fresh information of New Zealand, a comparatively small, open DC in the Asia-pacific region where macroeconomic forces are clearer and less convoluted than those in larger and more developed economies. Also, the regulatory level of NZ's Stock Exchange (NZSE) is not as great as those in other DCs (Gan *et al.*, 2006). NZ shows potentially strong growth for a capital market with its: reputation for political stability and investment prospective with significant foreign direct investments[3] including fast emerging oil and gas with under-explored basins; high-value low-cost opportunities including finance and real estate; strong ties to USA and proximity to the high growth Australasian markets; reduced tax on investments and movement to a systematic superannuation system with essential supporting underpinnings already in place. In 2001, the NZ government established the NZ Superannuation Fund (NZSF) with $2.4bn NZD and its value in June 2017 was $35.37billion NZD (NZSF Annual Report 2017)[2]; savings initiative Kiwisaver was commenced in 2007 and is growing rapidly. Though it is compulsory, it is somewhat different from Australian compulsory superannuation, as with Kiwisaver, the employers' contribution of 3% is compulsory only if the employee

[2] See the link https://www.nzsuperfund.co.nz/documents/2017-annual-report for details.

contributes[3]. However, because NZ superannuation is not compulsory and still at a formative stage, this study does not consider superannuation funds to explore the link.

ii) As a primary-product exporter and a price taker in world markets, NZ is sensitive to world prices encouraging investors to search for underlying factors which affect asset returns. Given these strong points and counterpoints, it is essential for investors to be well informed on changes and their effects on investment outcomes.

iii) It overcomes the limited static perspective of earlier research by using dynamic fast- and slow-moving-institutional-change models (Tylecote, 2016) to capture the significant changes in NZ such as economic liberalization over last three decades; floating of the exchange rate; lowering of trade protections; fiscal restraint and monetary deflation; drastic changes to government policies; and increasing policy concerns with aging population (see Appendix Table A1). Culpepper (2005) and Roland (2004) touched-off demand for more robust models in macroeconomic analyses, with fast-moving (formal) and slow-moving (informal) changes. Fast-moving (or formal) institutions, such as political and/or legal systems, do not necessarily change frequently but can change very rapidly, even overnight. Political and/or legal reform is often a necessary but insufficient condition for statistically significant fast-moving institutional changes, given that people's shared beliefs can persist even after changing the laws. Slow-moving (or informal) institutions are related to culture and include values, beliefs and social norms. The development of technology and scientific knowledge drives the evolution of culture. Slow-moving institutions change continuously, which produces inconsistencies with fast-moving institutions which, in turn, create pressures for fast changes. It is the interaction between slow-moving and fast-moving institutions that drive the institutional

[3] For details see http://www.kiwisaver.govt.nz/already/contributions/.

changes which, in turn, drives the dynamics of asset prices (Zhang *et al.*, 2017). An aging population and changing beliefs drive the evolution of culture and those changes precipitate change to slow-moving institutions, which drives fast-moving institutional change. Following the literature (Brown *et al.*, 1997; Zhang *et al.*, 2017), we use a structural break test to identify fast-moving institutional change and a time-varying-coefficient approach to detect slow-moving institutional changes in investigating the impact of changing demographic and macro-economic-variables on the NZ stock market.

iv) The use of monthly data (1991-2017) provides more detailed analysis than the quarterly data used by Huynh *et al.* (2006) to study the relationship between stock prices and demography. The higher-frequency data captures changes more effectively (Frazzini and Pedersen, 2014). However, quarterly data is used for the robustness check.

v) Unlike previous studies, this study provides a rationale for its selection of macroeconomic variables, by using an advanced *machine-learning-based* algorithm LASSO model (*least absolute shrinkage and selection operator*) (Tibshirani, 2011).

vi) It refines the pre-retirement target group from the 40-64 cohort (Huynh *et al.*, 2006) to the 55-64 cohort to adjust for the current workplace shift of retirement age from the 50s to 60s and often well beyond (i.e. people are living longer, healthier and stay in workplace longer than prior generations). This shift suggests that the first half of the previous cohort (i.e. the 40-50 cohort) are still saving and investing. Unlike previous generations who often lived for less than a decade after retiring, baby-boomers and subsequent generations fund three to five decades of retirement after age 65 working longer, retiring later, and/or investing more aggressively/strategically than earlier generations. Hence, the aging population is defined in this study as the proportion of age cohort 55-64 to total population. In addition, for the robustness check, the proportion of age cohort 55-64 to working population is used for more accurate study.

The empirical findings add to the knowledge of the business community and understanding of the NZ stock market in two respects: 1) Fast-moving-institutional-changes appear to be better match the unexpected market shocks (due to the more open economy) rather than changes in policies in terms of timing (see Appendix Table A2); and 2) Cointegration tests suggest that there is no long-run relationship with stock price and demographic factor. However, some macroeconomic variables such as real gross domestic product (GDP) and foreign portfolio investment (FPI) affect stock prices positively. The finding does not support the predictions of Life-Cycle Hypotheses (which is more confined to a closed economy) in New Zealand evidence. International factor mobility can mitigate the negative effect from aging population. Overall, our findings are mostly consistent with Acemoglu and Restrepo (2017).

In the rest of this study: Section 2 reviews the extant literature and hypotheses; Section 3 provides an overview of the methodology; Section 4 discusses the results; and Section 5 concludes the study, discusses its limitations and provides suggestions for future research.

2. Literature review and hypotheses development

2.1 Theoretical underpinning

2.1.1 Life Cycle Hypothesis (LCH), *Permanent Income Hypothesis (PIH) and Buffer stock Version of LC/PIH*

Income, consumption, savings/investment, and wealth accumulation shift during a person's life cycle and those shifts provide a basis for the enquiry into how the aging process and/or an aging population affects asset markets. If these processes and their interactions are poorly understood, related policies are likely to become unfit for purpose. Well-renowned, decades old, theories (e.g. standard LCH and PIH, Buffer-stock LC/PIH, Keynesian alternatives to the standard LCH and PIH frameworks, and the Campbell and Mankiw (1989) model) have long lent a strong theoretical underpinning to models of the effects of aging populations on asset prices. However, subsequent research has added to, challenged, and modified that understanding.

As mentioned previously, LCH suggests that people approaching retirement tend to open a new channel to allow them to offset dramatic reductions in their earnings with dis-accumulations from their accumulated wealth. As a result, as their life horizons shrink, older investors tend to become more risk averse and shift from high- to low-risk assets. The simplicity of LCH made it easy to understand and well accepted by policymakers, who found it convenient to shape/justify tools for macroeconomic predictions, via the rate of growth of national income and retirement plans. Steep demographic change, such as aging baby-boomers in DCs means that many formerly effective predictors (e.g. the simple channels elucidated in LCH) lose validity/power and it is vital that policy makers re-examine the foundations of their processes and procedures.

The standard LCH easily encompasses many complex variables (e.g. social security, tax change, bequests, government policy change, government-debt finance, labour productivity, and family size) in simple models (Modigliani, 1986). However, dynamic change in demography, markets, and transactions is making asset markets far more convoluted than what can be resolved by a simple LCH model, which increases the risk of spurious and chance outcomes in LCH based empirical investigations. These complications are exacerbated by market differences from country to country, financial assets being considered to be more volatile than real assets (e.g. housing). However, decades of market volatility suggests that housing prices can also vary considerably and unpredictably. Thus, whether the aging baby-boomer cohort is reacting to evolving global markets by using traditional LCH-defined channels/behaviours (i.e. cashing out risky stocks to transfer to low-risk assets and/or to fund current consumption) is question that is more tractable to empirical research than to theoretical reasoning.

If the baby-boom generation is less likely to cash-out risky stocks and invest in less-risky assets (e.g. cash and real assets), the much feared *stock-price melt-down* is likely to be a non-issue. Thus, the LCH simple prognostications of asset-price meltdowns must be netted against the effects of the current intense globalisation, rapid technological enhancements, and changing regulation on key macroeconomic variables.

However, the complexity of analysis depends on economic dynamism along with political and social factors. Specifically, according to asset pricing theory, factors influencing expectations of cash flows and/or discount rates will influence asset prices, and that opens the discussion to infinity of factors. Guidolin and La Ferrara (2010) found (in an *event-study* approach on the impact of conflicts on asset markets) that abnormal returns would have accrued when investors implement conflict-driven strategies. This shows the complexity of segmenting the cause and effect of asset markets.

Friedman (1957) PIH suggests a close long-term relationship between savings/investments and permanent income (Diamond, 1965). PIH states that people save only if their current income is higher than expected permanent income. Thus, when the aging population increases, PIH implies not only financial asset price headwinds but also house price headwinds. This is consistent with the findings of literature investigating the impact of ageing on financial asset prices (Takáts, 2010).

Among others, Carroll and Samwick (1997, p. 45) investigated the validity of standard LC/PIH models in clarifying income consumption relationship and developed Buffer-stock (BS) version of LC/PIH model. "Buffer-stock savers have a target wealth to - permanent-income ratio such that, if wealth is below the target, the precautionary saving motive will dominate impatience, and the consumer will save, while if wealth is above the target, impatience will dominate prudence, and the consumer will dis-save. While the standard LC/PIH model implies marginal propensity to consume (MPC) out of transitory income of 2 percent, the average MPC for consumers using BS model is always at least 15 percent, and ranges up to 50 percent implying much lower MPS rate than that in the standard LC/PIH model…. In terms of the relationship between future uncertainty and the spending patterns, Carroll assumes that the date of death is known with certainty, that there is no bequest motive, and that forms of uncertainty other than labour income uncertainty …do not intervene to boost the saving rate as consumers age". While it considered the transitory and precautionary saving motives, due to the strict assumptions after retirement the usefulness of it in explaining the behaviour of the aging population near and after their retirement and the resulting impact on asset markets is questionable. While an evaluation of Carroll and Samwick (1997) BS model is well beyond the scope of this paper, a decomposition of assets based on transitory and precautionary motives may provide useful information in for future research.

Since a majority of baby-boomers have passed the high-income-and-high-saving life stage and are entering or are well into the retirement-and-disinvestment life stage, it is vital to examine the possible impacts of their dissaving on the stock prices. Specifically, do they cash-in their accumulated relatively risky assets and buy traditionally less risky assets (e.g. houses, government bonds)? If a significant portion of the population follows such a path, what is the impact on the economy and are economic policies needed to maintain socioeconomic stability? While the theories and effects of demographic changes on asset prices have been greatly studied but the results have been mixed.

Goyal (2004) studied the links between population-age structure and net-stock-market outflows in an overlapping-generations framework and found supporting evidence for LCH with a positive relationship between net stock-market outflows and changes in the share of people in the over-65 cohort and a negative relationship between net stock-market outflows and changes in the share of people in the 45-64 cohort. Poterba (2004)[4] examining the age-specific patterns of asset holding in the United States found that asset holdings rise sharply when households are in their 30s and 40s. Though there was an automatic declined in the value of defined benefit pension assets as they come to the retirement, other financial assets declined only slowly during retirement. Also, in their predictions, there was no sharp decline in asset demand, questioning `asset-market meltdown'; and Abel (2001) supports this notion.

Hence, this study investigates whether the expected LCH in explaining the relationship between aging population and stock market can be validated when controlling for other macroeconomic variables and economic dynamism are taken into account. Our main hypothesis tests the LCH after increasing the age cohort to 55-64 as:

H1: There is a negative relationship between aging population and stock price.

A statistically significant negative coefficient for aging demography would favour the expected channels of LCH. Otherwise, the LCH is not supported by the data. In order to rule out the concern that the relationship between stock prices and demography might be overwhelmed by other variables, literature also considers a variety of macroeconomic variables. Following the existing literature (Poterba, 2001; Poterba, 2004; Huynh *et al.*, 2006), this study also incorporate various macroeconomic factors as control variables that can influence the stock prices and alleviate stock market meltdown.

Link between house price and demography was investigated by many using singly country data. Mankiw and Weil (1989) argued that the retirement of baby boomers would lead to an ‘‘asset price meltdown’’, a massive, almost 50%, real house price decline in less than two decades. On the others side, Engelhardt and Poterba (1991) found little demographic impact

[4] See Poterba (2001) for different modelling strategies used in examining equilibrium asset returns and population age structure.

(Takáts, 2010; Nishimura and Takáts, 2012). Examining 22 advanced economies from 1970 to 2009, Nishimura and Takáts (2012) found that demography affects house prices significantly where one percent higher total population is associated with around 1% higher real house prices. One percent higher old age dependency ratio corresponds to around 2/3% lower real house prices.

Bakshi and Chen (1994) found that housing prices had increased when the baby-boomers were in their 20s and 30s and (further) aging of the population affects asset prices negatively. When evaluating causes of financial instability and its influence on investment structure in Venezuela, Carvallo and Pagliacci (2016) found that neither house prices nor leverage seem to be crucial factors. Davis and Li (2003), when examining OECD countries over 50 years, found an increase in 40-64 cohort tends to increase real asset prices. Kapopoulos and Siokis (2005) argue that when the credit-price effect exists, a rise in housing prices can boost economic activity, and future profitability of firms which, in turn, drive stock prices. In order to rule out the concern that the stock prices are driven by house prices, we hypothesize:

H2: There is a negative relationship between aging population and stock price after controlling for house prices.

2.1.2 General Equilibrium Theory (GET)

The GET (developed in 1870s) explains the operations of markets as a whole and believes that any individual market is necessarily in equilibrium if all other markets are also in equilibrium. Research on the relationship between macroeconomic variables and stock market goes back a few decades. Chen (1991), referring to GET in a macroeconomic analysis, stated that characteristics of the macro-economy should be related to asset returns. Fama (1990) stated that the stock market can signal significant changes in the real-economy, along with *Flow-on-*

effects via economic dynamism from fast-growing regional markets. Other factors affecting stock-market prices include changes in regulation and financial market structures (Kwon and Shin, 1999). Dent (1998) notes that high-economic growth in the early 1990s was combined with baby-boomers being in a high-earnings/savings age. A historical view of capital market growth shows that a high level of market activity occurred in DCs during the robust economic conditions of 1990-2000, when baby-boomers were in their prime-earning/savings years. A few researchers have projected from the robust stock-market growth during the baby-boomer-generation-prime-earning period to forecast weak asset prices as they retire. Bakshi and Chen (1994) examined the relationship between the average age of the US populations and consumption, T-bill prices, and stock returns emphasizing Life Cycle Investment Hypothesis, found that investor's asset mix changes with their life cycle. They stated that business cycle patterns are partly due to demographic swings and an aging population drives an increasing risk aversion, accompanied with higher equilibrium risk premiums suggesting demographic movements can bring fluctuations in capital markets. Brooks (1999) examining 14 industrial countries found a positive correlation between the presence of a large working-age population and stock and bond price increases. Abel (2001) included bequests in examining the impact of rising retiring age on asset prices. Holtz-Eakin *et al.* (1993) found evidence that the individuals who receive (large) bequests tend to leave the labour market. As such, this study attempts to see the interaction of markets incorporating various macroeconomic variables in its analysis.

After considering the above arguments, we hypothesize[5]:

H3: There is a negative relationship between aging population and stock price after controlling real GDP and CPI;

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[5] We test the relationship between aging population and stock price by adding macroeconomic factors one-by-one. Otherwise, there might be a biased relationship between aging population and stock price.

H4: There is a negative relationship between aging population and stock price after controlling real GDP, *housing prices and CPI;*

H5: There is a negative relationship between aging population and stock price after controlling for the LASSO selected macroeconomic variables.

Further investigations warrants are whether this effect is offset by other macroeconomic variables or processes; if an equilibrium imbalance occurs, are there any corrective mechanisms (e.g. arbitrage) to restore stability? If selling pressure of assets is offset by the buying process (say through FDI), domestic capital markets can remain stable.

3. Data

Aging population is defined as the population in the 55-64 age cohort divided by total population (DEM_{55-64}). Following Acemoglu and Restrepo (2017), the proportion of population age cohort 55-64 to working age population is also used. Moreover, changes in population age cohort 55-64 has been used for the robustness check, however, the results are not reported here for the sake of brevity.[6] Following the literature (Chen, 1991; Granger *et al.*, 2000; Poterba, 2001; Poterba, 2004; Huynh *et al.*, 2006; Poterba, 2014) and the data availability, this study uses 11 variables (stock-price index (SPI); real gross domestic product (RGDP); housing-price index (HPI); 3-month interest rate (3MINT); 10-year government bond yield (GBY); exchange rate (EX) of New Zealand Dollar per US Dollar; money supply (M2); consumer price index (CPI); oil price (OLP); foreign-portfolio investment (FPI) and the focus variable aging population). Data availability restricts the period covered from 1991 to 2017.

Initially, few variables (DEM55-64 and RGDP) are taken at a quarterly frequency from 1991Q1 to 2017Q2. However, monthly data for the housing price index ranges from 1992M1-2015M3. Quarterly frequency data are approximated to a monthly frequency via cubic spline

[6] The results are available from the authors upon request.

interpolation[7]. Shifting to monthly data increases the number of observations from 106 to 316, which offsets the small-sample size and reduces the small-sample bias. All variables are transformed into natural logarithms. Except for SPI and HPI, the rest of the monetary variables are converted into real term based on the price level of 1991M3. The data description is reported in Appendix Table A3. For the robustness check, all the relevant empirical studies are re-estimated using the original quarterly data. Given that the findings based on monthly data and quarterly data are highly consistent, the main presentation of this study is based on the monthly data, however, all the results for the quarterly data are not reported here due to the space constraints.[8]

All the time-series data are sourced from *Datastream*; except oil prices, all variables are seasonally adjusted and expressed in NZ dollars; the Brent oil price is in US dollars. Based on the Statistics New Zealand, baby-boomer births are considered to have occurred from 1947-1966. In 1991, baby boomers were 25-44 years and in 2017 they were 51-70 years old. In 1991, early baby-boomers were in their high-earnings/saving/investment period (LCH) and late baby-boomers were entering and/or settling into their earnings and arranging their consumption/investment decisions. In 2017, the early baby-boomers were entering retirement age and the late baby-boomers were entering their high-earnings/saving/investment period. As mentioned earlier, people are living longer and staying longer in the workplace than prior generations, this study considered the pre-retirement cohort to better represented by ages 55-64 years than the often used broader range of 40-64.

4 Research Design

4.1.1 Unit root and structural-break tests for fast-moving institutional changes

[7] The cubic spline interpolation provides a piecewise continuous curve, passing through each of the values in the quarterly frequency.
[8] The results are available upon request from the authors.

In investigating *Fast-moving* institutional changes, this study (unlike Furuoka (2016) which allows for only one structural break), uses Clemente *et al.,* (1998) unit root test as it considers two structural breaks (Ben-David *et al.*, 2003) which is more appropriate for this study with double unknown structural-breaks. It is essential to test the existence of a unit root when using time-series data for model estimation, failure to do so violate the standard asymptotic distribution theory, resulting in model misspecification, coefficient bias and spurious estimation inferences. Traditionally, Augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) tests are used to assess the order of integration of the variables. A weakness of the ADF and PP unit root tests is their potential confusion of structural-breaks in the series as evidence of non-stationarity (they may fail to reject the unit root hypothesis if the series have a structural-break); for the series that are found to be $I(1)$, there may be a possibility that they are in fact stationary around the structural-break(s), $I(0)$, but are erroneously classified as $I(1)$. Perron (1989) shows that failure to allow for an existing breaks leads to a bias that reduces the ability to reject a false unit root null hypothesis. Following this development, researchers proposed determining the break point 'endogenously' from the data and the unit root tests allow for one structural-break (Perron and Vogelsang, 1992; Zivot and Andrews, 1992), whereas the Clemente *et al.,* (1998) unit root test allows for two structural-breaks in the mean of the series.[9] The two forms of structural-break are: i). The *Additive-Outlier* (AO) model, which is more relevant for series exhibiting a sudden change in the mean (the crash model); and ii). The *Innovational-Outlier* (IO) model which is designed to capture gradual changes over time. This study uses both AO and IO models to make more robust conclusions about the time series properties of the data series under investigation. Moreover, structural-breaks in AO and IO model can signal the existence of fast-moving and slow-moving changes in NZ economy.

[9] The time span of data in this study is not very long; hence, two structural breaks for each time series variable are reasonable.

If the estimates of Clemente *et al.,* (1998) unit-root test with two structural-breaks in AO and IO model show that there is no evidence of a statistically significant second break in the series, the original Perron and Vogelsang (1992) techniques should be used to test for a unit root in the presence of one structural-break. If the first structural-break is not statistically significant, the ADF unit root test is used to examine whether the underlying variable is statistically stationary. The work begins with Clemente *et al.,* (1998) unit root test with two unknown structural breaks.

Tables 1 and 2 present the structural-break-test results for detecting slow- and fast-moving institutional changes in NZ stock prices using the IO and AO models, respectively. The results for both IO and AO models suggest that all the variables except DEM and CPI are statistically stationary after taking first log difference. The DEM and CPI are integrated of order 2. In addition, statistically significant structural-breaks for both the AO and IO models indicate the evidence of both fast- and slow-moving institutional changes in NZ's economy. Apart from the first difference of the natural log of the housing-price index $\Delta LnHPI_t$, the first difference of the natural log of the 3-month interest rate $\Delta Ln3MINT_t$ and the first difference of the natural log of the real gross domestic product $\Delta LnRGDP_t$, all the rest stationary variables show more significant t-statistics for the IO model than the AO model. The significant political events are shown (Table A2) by comparing the dates of structural breaks reported in Tables 1 and 2. It seems the structural breaks are likely to match the unexpected market shocks rather than anticipated political or legal changes. Many structural-breaks are evident within a short time, especially between 2008 and 2010. Hence, the most significant structural-break, close to the period of subprime-mortgage crisis 2008M3 is considered for the analysis. Two dummy variables are created for the structural-break for the period 2008M3: a set of dummy variables: i) D=1 for 2008M3 only (to examine the temporary shock); ii) D=1 for the subsample from 2008M3 to 2017M6 (to examine the effect of crisis over time). Likewise, for the quarterly data,

i) D=1 for 2008Q2 only (to examine the temporary shock); ii) D=1 for the subsample from 2008Q2 to 2017Q2 (to examine the effect of crisis over time).

[TABLE 1 and TABLE 2 ABOUT HERE]

4.1.2 The LASSO regression for the selection of macroeconomic variables

The relevant macroeconomic variables are determined by LASSO selection method[10] which reduces the effects of multicollinearity, the variance of the model and the mean square error. The LASSO regression result is reported in Table 3. Using Mallow's C_p, the number of covariates is determined. The C_p statistic is defined as a criterion to assess fits when models with different numbers of parameters are compared (Efron *et al.*, 2004a; Efron *et al.*, 2004b; Zou *et al.*, 2007; Kato, 2009). If model (p) is correct then C_p will tend to be close to, or smaller than p. The LASSO regression incorporates HPI, exchange rate, money supply, 3-month interest rate, real GDP, oil prices, 10-year-government-bond yield, foreign portfolio investment, and differenced CPI (which measures inflation rate) against the dependent variable the stock price index, and all the variables in Table 3 are log differenced to make them stationary. The result shows that the smallest value for C_p is achieved after the nine steps of running regressions. So, the LASSO selects the following eight macro-economic variables as the control variables for the hypothesis 5: HPI, money supply, 3-month interest rate, real GDP, oil price, 10-year government bond yield, inflation rate, and foreign portfolio investment.

[TABLE 3 ABOUT HERE]

4.1.3 Cointegration test for long-run relationship between stock price and demography

Johansen cointegration test: Examination of the long-run relationship of the proposed hypotheses is most efficiently done by testing and estimating the cointegrating relationships of $I(1)$ series. The Johansen cointegration test provides two likelihood ratio tests for the number

[10] Least absolute shrinkage and selection operator (LASSO) shrinks some coefficients and sets others to 0 and hence tries to retain the good features of both subset selection and ridge regression (Tibshirani, 2011).

of cointegrating vectors the: i) *Maximal eigenvalue test*, which tests the null hypothesis (*there are at least* r *cointergration vectors*), vs. the alternative (there are $r + 1$); and ii) *Trace-test*, with the alternative hypothesis of *the number of cointegrating vectors equals or is less than* $r + 1$.

Given that there are structural-breaks at the log level, it is preferable to split the whole sample into subsamples before applying the cointegration test. Alternatively, to capture the regime change, the dummy for the particular period of the structural-break is constructed for the co-integration test. The results of the cointegration test employing Johansen's maximum likelihood techniques for dummy variable for 2008M3 only and dummy variable for 2008M3 - 2017M6 are reported in Table 4 panel A and panel B, respectively. All the variables in Table 3 are I(1) non-stationary for cointegration which refers to long-run or equilibrium relationship between non-stationary variables (Granger *et al.*, 2000; Farmer, 2015). Hence, the dependent variable is stock price rather than stock return. Both panels show the results of the five hypotheses tested with zero and at most one cointegrating vectors using trace and maximum eigenvalues test statistics generated from the maximum long run test statistic. It can be said from panel A that, for hypothesis 1, no cointegration is found between the stock price and baby-boomers' demography; suggesting that there is no long-run relationship between the stock market and aging baby-boomers. The finding is consistent with the US (Poterba, 2001; Poterba, 2004) but contrasts to the findings in Australia (Huynh *et al.*, 2006).

However, there is a deterministic trend in models 2-4 that can be ascertained from the trace and eigenvalue statistics that at least one cointegration relationship is found for the hypotheses 2-4. However, for hypothesis 5, the Johansen cointegration trace test suggests that there are four statistically significant cointegrations at the 5% significance level. On the other hand, the Johansen cointegration Maximum-Eigenvalue test suggests that there is one statistically significant cointegration at the 5% significance level. For the sake of prudence, we use the first cointegration for models 2 through 5. It can be ascertained from the Max-EV and trace statistics that (Table 4, panel A) stock price index $LnSPI_t$, log changes in demography $\Delta LnDEM_t$, house price index $LnHPI_t$, real GDP $LnRGDP_t$, and inflation $\Delta LnCPI_t$ are cointegrated, for example hypothesis 4. The results of models 2 through 5 show that there exists a linear combination of the $I(1)$ variables that links them in a stable long-run relationship, which in turn reflect that macroeconomic factors are important to be considered. The finding in models 3 and 4 are mostly consistent with Huynh *et al.* (2006). The results can be explained by the fact that number of key macroeconomic variables (e.g. output, inflation, interest rates) as significant determinants of stock market movements (Dickinson, 2000). The results are roughly the same for the dummy variable 2008M3 to 2017M6. For the robustness check, we also estimated Model 6 considering all the regressors and the finding is highly consistent with Model 5.

[TABLE 4 ABOUT HERE]

When the variables such as $LnSPI_t$, $\Delta LnDEM_t$, $LnHPI_t$ and $LnRGDP_t$ for the model (for example hypothesis 4) are found to be cointegrated, then there must exist an associated ECM, which may take the following forms:

$$\Delta lnSPI_t = c + \sum_{i=1}^{p} \omega_i \, \Delta LnSPI_{t-p} + \sum_{j=1}^{p} \beta_{1j} \, \Delta\Delta LnDEM_{t-p} + \sum_{k=1}^{p} \beta_{2k} \, \Delta LnHPI_{t-p} + \sum_{l=1}^{p} \beta_{3l} \, \Delta lnRGDP_{t-p} + \rho_1 CI_{(t-1)} + \varepsilon_t \quad (1)$$

Where, c denotes the constant. ΔΔ denotes the second difference operator. $CI_{(t-1),}$ is the error correction term; p is the lag lengths (determined by Bayesian Information Criterion; BIC); and ε_t is random disturbance terms. The series will converge to the long-run equilibrium if $-1 \leq \rho_1 < 0$ holds, but cointegration implies that $\rho_1 \neq 0$. Further, the Johansen cointegration test is performed with structural-breaks (Farmer, 2015). The coefficients for log changes in the relevant variables measure short-run elasticities, and the coefficient for error correction term represents the speed of adjustment of going back to the long-run relationship between the variables.

Bounds-testing approach: as a robustness check, this study also employs the Autoregressive-Distributed Lag (ARDL) based bounds cointegration test. The bounds test is quite useful when variables are in different orders of integration and limited number of observations (Granville and Mallick, 2004). However, the bounds-testing approach can accommodate only one co-integrating relationship (Pesaran *et al.*, 2001). In practice, it is quite difficult priori to confirm the number of cointegrations for the multivariate regressions. Hence, this study applies bounds-testing approach in hypothesis 1 only for the sake of prudence.[11] To implement the bounds-testing procedure, it is essential to estimate a conditional autoregressive distributed lag model (ARDL), as follows:

$$\Delta lnSPI_t = c + \theta_1 LnSPI_{t-1} + \theta_2 \Delta LnDEM_{t-1} + \sum_{i=1}^{p} \omega_i \,\Delta LnSPI_{t-i} + \sum_{j=0}^{p} \beta_j \,\Delta\Delta LnDEM_{t-j} + \varepsilon_t \qquad (2)$$

The bounds-test for examining evidence for a long-run relationship can be conducted using the *F*-test. The *F*-test statistic tests the joint significance of the coefficients on the one period lagged levels of the variables in equation (2), that is, H_0: $\theta_1 = \theta_2 = 0$. The asymptotic distribution of critical values is obtained for cases in which all independent variables are purely *I*(1) as well as when the independent variables are purely *I*(0) or mutually cointegrated.

The *F* test has a non-standard distribution which depends on: a) whether variables included in the ARDL model are *I*(0) or *I*(1); b) the number of independent variables; c) whether the ARDL model contains an intercept and/or a trend; and d) the sample size. The two

[11] ARDL model was introduced by Pesaran *et al.* (2001) in order to incorporate I(0) and I(1) variables in same estimation so if the variables are stationary I(0) then OLS is appropriate and if all are non-stationary I(1) then it is advisable to do VECM (Johanson) approach as it is a much simpler model.

sets of critical values provide critical value bounds for all classifications of the independent variables into purely $I(1)$, purely $I(0)$ or mutually cointegrated. If the computed F statistic is higher than the upper bound of the critical value then the null hypothesis of no cointegration is rejected (Pesaran *et al.*, 2001).

Table 5 reports the Pesaran *et al.,* (2001) ARDL cointegration test results for hypothesis 1, the estimated F-statistic is 1.689 less than the lower bound critical value of 4.94 at the 5% confidence level. The result suggests that the null hypothesis of no cointegration cannot be rejected with regime change (dummy variable = 2008M3). The same conclusion can be drawn for the dummy period 2008M3 to 2017M6 (right panel, Table 5). Both the results do not verify a long-run relationship between stock price $LnSPI_t$ and log changes in demography $\Delta LnDEM_t$ over 1991-2017 with monthly frequency. The test results corroborate the results of Johansen testing approach, leading to the conclusion that there is compelling evidence that stock market and baby-boomers demography are not cointegrated if we exclude macroeconomic factors.[12]

[TABLE 5 ABOUT HERE]

4.1.4 Time-varying parameter with error correction model *for slow-moving institutional changes*

Although IO model in Table 1 is able to test the existence of slow-moving institutional changes, it cannot quantify the level of slow-moving institutional changes by nature. Hence, the level of slow-moving institutional changes are quantified using the State-space based time-varying parameter (TVP) models which consists of two equations: i) measurement-equation; and ii) state- equation with random-walk specification which is appropriate when there are changes in the policy regime (Brown *et al.*, 1997):

[12] Given there is no statistically significant cointegration between $\Delta LnDEM_t$ and $LnSPI_t$, the significantly negative coefficient on $\Delta LnDEM_t$ might be biased. Hence, we do not rely on coefficient for inference.

Measurement-equation:

$$\Delta LnSPI_t = c + sv_{1,t}\Delta\Delta LnDEM_t + sv_{k,t}C_{k,t} + \varepsilon_t \quad (3)$$

State-equation with random-walk specification:

$$sv_{k,t} = sv_{k,t-1} + u_t \quad (4)$$

$$(\varepsilon_t, u_t)' \sim N\left(\begin{pmatrix}0\\0\end{pmatrix}, \begin{pmatrix}\sigma^2 & 0\\ 0 & Q\end{pmatrix}\right) \quad (5)$$

Where, $\Delta lnSPI_t$ stands for the first natural log differenced stock price index; $sv_{k,t}$ is the time-varying coefficient for the $k\text{-}th$ control variable at time *t*; $C_{k,t}$ is the $k\text{-}th$ control variable at time t; $\Delta\Delta lnDEM_t$ is the second log differenced demography variable; c is the constant; ε_t and u_t are temporary- and permanent-disturbance terms, respectively, ε_t and u_t are Gaussian disturbances, which are serially independent as well as independent of each other over the sample. Once the TVP models are specified as equations (3) through (5), the time-varying coefficients $sv_{k,t}$ can be estimated by using a Kalman filter. The state-space model has three unknown parameters $\Psi = \left(c, \sigma^2_{\varepsilon_t}, \sigma^2_{u_t}\right)'$. The symbol Ψ is a *hyper-parameter* and is estimated with Maximum Likelihood Estimation (MLE), using the Marquardt algorithm (Van den Bossche, 2011).

In order to investigate the long- and short-run effects of demographics and other macro-economic variables on stock returns, the measurement equation of state-space model takes the form of the Error-Correction Model (ECM) shown in equation (1) when the underlying variables are cointegrated. The time-varying coefficients $sv_{k,t}$ for the five models over 1991M3-2017M6 are shown in Figure 1. The time-varying parameter for the second difference of demography (or $\Delta\Delta LnDEM_t$) in hypotheses 1-4 suggest that the coefficients are positive but declined between 1994M1 and 1999M12 albeit they experienced various levels of spikes in the short-run especially in the beginning months till 1993; the coefficients remain negative from 1999 to 2002; thereafter, the coefficients stabilize at a positive value. The results for hypothesis

5 after incorporating eight macroeconomic variables using LASSO selection criteria imply that the eight macroeconomic factors, in general, play a declining role in driving the log changes in stock prices ($\Delta LnSPI_t$) over 1991M3-2017M6. More specifically, in hypothesis 5, the coefficient for the log changes in growth rate of baby-boomer demography ($\Delta\Delta LnDEM_t$), remains negative prior to 2002M5 and positive thereafter, and the coefficient shows a "W" pattern from 2006M1 to 2013M5. The coefficient for log changes in house price ($\Delta LnHPI_t$), shows sharp ups and downs till 2001M3 and then increases from -0.2 in 2001M4 to 0.2 in 2010M6. The coefficient for log changes in real GDP ($\Delta LnRGDP_t$) increases from 1994M5 to 1999M2 and then declines without significant recovery by 2017M6. The coefficients for log changes in inflation ($\Delta\Delta LnCPI_t$), log changes in 3-month interest rate ($\Delta Ln3MINT_t$), log changes in oil price ($\Delta LnOLP_t$) and log changes in foreign portfolio investment ($\Delta LnFPI_t$) tend toward to zero over-time. The coefficient for log changes in money supply ($\Delta LnM2_t$) declines sharply from 0.2 in 1997M11 to -0.25 in 2002M11, and then remains stable. The coefficient for log changes in 10-year government bond yield ($\Delta LnGBY_t$) declines from 0.2 in 1996 to -0.3 in 1999 and then rebound to -0.05 in 2012. In general, the signs for the coefficients for cointegration are positives prior to 1995, indicating that the self-correction process could drive the stock market away from equilibrium occasionally. Thereafter, the coefficients for the cointegration terms are negatives by 2017M6, suggesting that market forces will drive stock market converge to equilibrium over-time. The turning points for coefficients appear in 1998M09-2000M09 and 2008M03-2009M05 in Figure 1 are roughly consistent with unit root test results reported in Table 1 and Table 2.

[FIGURE 1 ABOUT HERE]

The results of the hypotheses tests for statistical significance of the TVPs are shown in Table 6. In models 1 through 5, the coefficients for log changes in real GDP ($\Delta LnRGDP_t$) are statistically significant and positive at the 5% significance level. While the coefficients for log changes in money supply ($\Delta LnM2_t$) and error correction term are significantly negative at the 5% significance level. The coefficient for log changes in foreign portfolio investment ($\Delta LnFPI_t$) is positive and significant at the 10% significance level. Overall, the results so far suggesting that log changes in real GDP and log changes in foreign portfolio investment play significant and positive role on stock return; surprisingly, log changes in real money supply play negatives role. All the rest of the coefficients are statistically insignificant at the conventional significance levels. In other words, economic growth and log changes in foreign portfolio investment boosts stock market activities. However, log changes in real money supply show the opposite effect. Furthermore, speculative or market shocks could drive stock prices away from market equilibriums in the short-run, but fundamentals will cause stock prices to converge to an equilibrium in the long-run.

[TABLE 6 ABOUT HERE]

The finding of *no evidence of baby boomers demography influencing stock market prices* is consistent with Poterba (2001) and stand in contrast to the channels displayed in LCH as well as general equilibrium models for stock markets. The results reveal that the short-run volatility might be explained, in part, by irrational behavior on the part of investors (Shiller, 1990; Zhang *et al.*, 2015) and other factors. One way to construe the findings would be that, even when changing demography affects the stock market, the power and the speed of the changes are so small that they are washed out by other effects. Given that fast-moving information technology plays a crucial role in economic growth (Colecchia and Schreyer, 2002), technology-based productivity growth may accelerate economic growth and mitigate the expected negative influence of the changing $DEM_{55\text{-}64}$ on the stock market. Acemoglu and Restrepo (2017) argue that the lack of negative impact of population aging on growth of GDP per capita is possibly due to growing adoptions of robot technologies replacing labours. Moreover, along with advancement of technology, skilled migration policy can boost labour productivity and accelerate economic growth which, in turn, affect stock markets positively. The positive relationship between productivity and stock prices is evident (Figure 2), which support the view and consistent with Acemoglu and Restrepo (2017). Also, while the sampling period is long enough to suggest relationships, it needs to be longer to make significant conclusions about future effects. However, macroeconomic factors such as real GDP and FPI are likely to play a key role in driving the NZ stock prices (at least, in the short-run),

[FIGURE 2 ABOUT HERE]

4. 6 Diagnostic tests

In assessing whether the five two-step TVP models are valid, Table 7 reports the standardized prediction errors of the five TVP models in terms of independence, homoscedasticity and normality, which are listed in a decreasing order of importance (Commandeur and Koopman, 2007). As the measure of the relative quality of a statistical model, Table 7 also presents both the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC).

[TABLE 7 ABOUT HERE]

The Ljung-Box and the McLeod-Li tests fail to reject the residual independence and the residual homoscedasticity for models 1 to 5, respectively (Table7). The Jarque-Bera test significantly rejects the normality of residuals for the model 1. Table 7 indicates that the models 2-4 meet the three assumptions concerning the residuals of the analysis. The model 1 is somewhat problematic but still provides sensible outputs, given that the residual normality is the least important assumption. Model 5 reports the smallest AIC and BIC, and, thereby, provides the best estimation. Overall, the findings of the five applied TVP models are valid.

4.7 Robustness checks

The study performed various checks to verify the finding that an aging population does not influence stock market negatively is robust. The scatter plots of DEM and SPI shown in Figure

3 demonstrate a positive trend of both DEM and SPI. The correlation between DEM and SPI is above 0.67, which is quite high. The robustness checks undergone in this study are: i) estimations are conducted using both monthly and quarterly data; ii) nominal and real terms; iii) aging population relative to total population as well as working age population; iv) changes in population age cohort 55-64; and v) using demographic variable with log and without log. The results are consistent and reveal that an aging population and stock prices are not negatively correlated in New Zealand which is contrary to the LCH and PIH predictions.[13] Various macroeconomic factors are considered to examine the relationship between the two. The finding is robust and suggests that macroeconomic factors such as real GDP, money supply and foreign portfolio investment influence stock market.

[FIGURE 3 ABOUT HERE]

5. Conclusion

5.1 Summary

This study evaluates the long-run influence of changing demography (as proportion of population age cohort 55-64 to total as well as working age population) - individually and in combination with other macro-economic factors - on stock prices, using NZ monthly and quarterly data (1991-2017). The dynamic perspective of the influence of macroeconomic factors on stock prices employing fast- and slow-moving-institutional changes is examined for the first time using NZ data.

The structural-break test with additive and innovational outliers, state-space model based error correction model are employed to study the short-run and long-run effects of institutional change of each independent variable. The *least absolute shrinkage and selection operator* (LASSO) model is used to select crucial macroeconomic variables that

[13] The results for the robustness check are not all reported here, available upon request from the authors.

can influence the NZ stock market. This study considers a range of non-demographic factors such as money supply, foreign portfolio investment, ten-year government bond yield and oil price (ignored in many studies) as control variables. The findings of this study suggest that there is no long-run relationship with stock price if demographic factor is considered alone. The relationship between the two does not change when other macroeconomic factors are considered. However, some macroeconomic factors become an important part of explaining stock price changes. In other words, stock market is cointegrated with macroeconomic fundamentals and ignoring macroeconomic factors may misinterpret the relationship between stock price and aging population. Macroeconomic factors like real GDP and foreign portfolio investment boost stock prices. Our results are robust to a set of sensitivity checks, considering three different measures of aging population, quarterly vs. monthly data, nominal vs. real variables and with and without log of demographic variable.

Another key issue suggested by this study is that, due to improved health and lengthening work-lives, the commonly used 40-64 pre-retirement cohort might best be split into a 40-49 working cohort and a 55-64 pre-retirement cohort. Also, future studies should continually reconsider this evolving issue; for example, the ≥65 cohort might best be separated into 65-69 and ≥70 cohorts to reflect changes to health, attitudes, and retirement prospects. The on-going nature of such changes suggest that pre- and post-retirement cohorts should be constantly reconsidered.

These findings reveal that adjustments to sustain the market equilibrium occur mainly via changes in, money supply, real GDP, government-bond yield, housing price and foreign-portfolio investment. These variables help establish market equilibrium after a disturbance and can be summarized as arbitrage/market-efficiency processes. Furthermore, the results suggest that unexpected market shocks are associated with fast-moving institutional changes than policy changes in terms of timing.

While the effect of changing demographics, increased longevity and flow-on effects on stock markets are well researched for other DCs, the relatively small size of the economy, low political risk, NZ economy provides an excellent case study. This study differs from earlier studies in that it uses a more sophisticated LASSO selection method in selecting the macroeconomic variables.

The findings of this study should be of interest to: policy makers in their role of sustaining socio-economic growth; investors in their search for timely insights on global conditions; and researchers as globalization integrates investment markets and puts many well-researched relations into flux. Unlike many earlier studies, which promote the need for policy intervention to avoid a market meltdown, this study suggests that retirement of the baby boomer generation is unlike to produce *such-meltdown* because arbitrage via macroeconomics variables pressure asset prices to revert to their market-efficient level. Thus this study suggests that increasing productivity through international trade, better education and training to labour force might play a crucial role in enhancing economic growth and boosting stock market prices in New Zealand. The fast developing information technology can be the prime factor that raises productivity as well as economic growth. Moreover, skill composition of the immigrant flow can potentially generate economic gains for a country by increasing productivity. Hence, policies towards capital formation and substitute aging population by skilled migrations may assist the stock market to grow.

5.1 Limitations and future research:

As mentioned previously, this is a single country study and investigates a single asset market. However, it paves the way forward for multi-country comparisons, with inclusion of variety of assets, covering a longer data period when current restriction of non-availability of data is no longer a problem. Researchers should allow for demand-supply relationships, as the rising demand for NZ stock market from less-stable emerging economies due to NZ's political stability makes it a desirable destination and may affect the overall market. This study (due to the complexity and the non-availability of accurate data) did not examine the effect of bequests (with demographic changes) or separate the target population by employment type and/or their impact on asset prices. Specifically, retirement age often varies with employment type. Thus, a review of how different employment groups affect investment decisions at retirement age would be a valuable contribution. As the relatively new NZ superannuation industry has a growing investment portfolio, more comparative studies would provide essential information for policy decisions. While the findings address a major concern across most DCs, as a general caution, care should be exercised in applying the findings of this study to other countries, and or time periods. Last but not the least, it remains curious whether the insignificant relationship between aging structure and stock prices is due to NZ baby-boomers traditionally invest in other asset classes rather than equities.

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Table 1 Unit root test with structural-breaks: IO Model

Unit Root Test with Two Endogenous Structural Breaks: Clemente et al., (1998) Test					
Variables	Min t (Level)	Break Points (Level)	Min t (1st Difference)	Break Points (1st Difference)	Result
Exchange rate ($LnEX_t$)	-4.282	1997m5***, 2002m8***	-8.982**	2008m5***, 2009m1***	I(1)
Housing price index ($LnHPI_t$)	-3.09	2001m12***, /	-5.493**	2001m12***, 2007m4***	I(1)
Money supply ($LnM2_t$)	-3.054	1998m6***, 2010m12***	-5.962**	2008m10***, 2010m7***	I(1)
3M Interest rate ($Ln3MINT_t$)	-4.034	1998m2**, 2008m8***	-6.905**	2008m9***, 2008m12***	I(1)
Real GDP ($LnRGDP_t$)	-0.871	/, /	-5.617**	2008m1***, 2009m1***	I(1)
Oil price ($LnOLP_t$)	-4.021	1998m11***, 2004m3***	-5.711**	2008m9***, 2009m1***	I(1)
% Pop age 50-64 ($LnDEM_t$)	-3.426	1996m2***, 1999m9**	-3.609	1996m1***, 2011m3***	I(2)
% Pop age 50-64 (DEM_t)	-3.053	1996m2***, 1999m9*	-3.668	1998m1***, 2011m3***	I(2)
% Pop age 50-64 ($DEM_{W,t}$)	-3.100	1999m11***	-4.698	2000m3***, 2002m10***	I(2)
% Pop age 50-64 ($LnDEM_{W,t}$)	-3.892	1999m11***	-5.041	2000m3***, 2002m10***	I(2)
Stock price index ($LnSPI_t$)	-2.646	2003m2**, /	-14.843**	2007m9***, 2009m2***	I(1)
10Y bond yield ($LnGBY_t$)	-4.802	1997m3***, 2011m3***	-12.304**	/, /	I(1)

CPI ($LnCPI_t$)	-3.118	1999m11***, 2007m8**	-4.87	2010m8***, 2010m11***	I(2)
FPI ($LnFPI_t$)	-2.542	2008m9***, 2008m11***	-11.162**	2008m11***, 2009m3***	I(1)

Notes: Innovational Outliers (IO) model allowing for a gradual shift in the mean of the series. Min t is the minimum t-statistic calculated. Triming = 10%. The value of optimal lag length was selected following the procedure suggested in Perron and Vogelsang (1992). The max length is 12. The 5% critical value for the IO model is -5.490. * denotes 10% level of significance for structural break. ** denotes 5% level of significance for structural break. *** denotes 1% level of significance. There are negative values FPI, so constants are added to the variable that ensure the minimum value equal to 1. $LnDEM_t$ and $LnCPI_t$ are integrated of order 2. $DEM_{W,t}$ is the proportion of population in the age group 55-64 to the working age population.

Table 2 Unit root test with structural-breaks: AO Model

Unit Root Test with Two Endogenous Structural Breaks: Clemente et al., (1998) Test					
Variables	Min t (Level)	Break Points (Level)	Min t (1st Difference)	Break Points (1st Difference)	Result
Exchange rate ($LnEX_t$)	-3.919	1998m9***, 2003m6***	-5.546**	2008m8*, 2009m3**	I(1)
Housing price index ($LnHPI_t$)	-2.047	2002m12***, 2005m3***	-5.51**	2001m11***, 2007m5***	I(1)
Money supply ($LnM2_t$)	-2.832	2001m10***, 2012m7***	-12.417**	/, /	I(1)
3M Interest rate ($Ln3MINT_t$)	-4.37	1998m11***, 2009m2***	-5.579**	2008m11***, 2009m6***	I(1)
Real GDP ($LnRGDP_t$)	-2.173	2001m7***, 2007m10***	-5.598**	2008m1***, 2009m1***	I(1)
Oil price ($LnOLP_t$)	-3.944	1999m11***, 2004m1***	-5.574**	2008m9***, 2009m1***	I(1)
% Pop age 50-64 ($LnDEM_t$)	-2.929	2002m8***, 2008m8***	-3.367	1997m6***, 2012m3***	I(2)
% Pop age 50-64 (DEM_t)	-3.052	2002m8***, 2009m7***	-3.200	1998m12, 2012m3	I(2)
% Pop age 50-64 ($DEM_{W,t}$)	-2.917	2002m8***, 2010m1***	-4.032	2000m5***, 2002m10***	I(2)
% Pop age 50-64 ($LnDEM_{W,t}$)	-3.819	1999m11***	-4.724	2000m3***, 2002m10***	I(2)
Stock price index ($LnSPI_t$)	-2.372	2004m8***, 2008m3***	-14.938**	2007m11***, 2008m12***	I(1)

10Y bond yield ($LnGBY_t$)	-4.815	1997m12***, 2010m11***	-12.304**	/, /	I(1)
CPI ($LnCPI_t$)	-2.637	2002m7***, 2008m10***	-4.776	1998m8***, 2010m8***	I(2)
FPI ($LnFPI_t$)	-2.837	2008m10***, /	-9.044**	2008m10**, 2009m1**	I(1)

Notes: Additive outliers (AO) model captures a sudden change in a series. Min t is the minimum t-statistic calculated. Triming = 10%. The value of optimal lag length was selected following the procedure suggested in Perron and Vogelsang (1992). The max length is 12. The 5% critical value for the AO model is -5.490. There are negative values FPI, so constants are added to the variable that ensure the minimum value equal to 1. $LnDEM_t$ and $LnCPI_t$ are integrated of order 2. $DEM_{W,t}$ is the proportion of population in the age group 55-64 to the working age population.

Table 3 LASSO regression

Step	Cp	R-square	Action
1	19.4972	0.0000	
2	16.8718	0.0536	+$\Delta LnHPI_t$
3	15.9228	0.1106	+ $\Delta LnM2_t$
4	14.5635	0.1281	+$\Delta LnFPI_t$
5	14.4173	0.1383	+$\Delta Ln3MINT$
6	13.8201	0.1909	+ $\Delta LnRGDP_t$
7	13.6048	0.2314	+$\Delta\Delta LnCPI_t$
8	9.5172	0.2364	+$\Delta LnGBY_t$
9	9.0000*	0.2470	+$\Delta LnOLP_t$

Notes: The macro variables considered for the LASSO regression are: $\Delta LnHPI_t$, $\Delta LnEX_t$, $\Delta LnM2_t$, $\Delta Ln3MINT_t$, $\Delta LnRGDP_t$, $\Delta LnOLP_t$, $\Delta LnGBY_t$, $\Delta LnFPI_t$, $\Delta\Delta LnCPI_t$ and the variables actually selected are noted in the action column. The dependent variable is $\Delta LnSPI_t$, and all the variables are stationary at I(0). * indicates the smallest value for Cp.

Table 4 Johansen Cointegration Test: Panel A

Model 1: $LnSPI_t = c + \beta_1 \Delta LnDEM_t + \beta_2 Dummy_{2008M3} + \varepsilon_t$: Life cycle hypothesis			
0 CI vectors		At most 1 CI vectors	
Trace Test Statics	Max-EV Test Statics	Trace Test Statics	Max-EV Test Statics
9.5553	8.3762	1.1791	1.1791
Model 2: $LnSPI_t = c + \beta_1 \Delta LnDEM_t + \beta_2 LnHPI_t + \beta_3 Dummy_{2008M3} + \varepsilon_t$: Credit effect hypotheses			
0 CI vectors		At most 1 CI vectors	
Trace Test Statics	Max-EV Test Statics	Trace Test Statics	Max-EV Test Statics
28.922*	20.9413*	6.9813	6.8245
Model 3: $LnSPI_t = c + \beta_1 \Delta LnDEM_t + \beta_2 LnRGDP_t + \beta_3 \Delta LnCPI_t + \beta_4 Dummy_{2008M3} + \varepsilon_t$: General Equilibrium theory			
0 CI vectors		At most 1 CI vectors	
Trace Test Statics	Max-EV Test Statics	Trace Test Statics	Max-EV Test Statics
49.757**	25.677*	24.0801	12.219
Model 4: $LnSPI_t = c + \beta_1 \Delta LnDEM_t + \beta_3 LnRGDP_t + \beta_2 LnHPI_t + \beta_4 \Delta LnCPI_t + \beta_5 Dummy_{2008M3} + \varepsilon_t$: General Equilibrium theory			
0 CI vectors		At most 1 CI vectors	
Trace Test Statics	Max-EV Test Statics	Trace Test Statics	Max-EV Test Statics
66.834*	34.8415**	38.992	17.824
Model 5: $LnSPI_t = c + \beta_1 \Delta LnDEM_t + \beta_2 HPI_t + \beta_3 LnRGDP + \beta_4 Ln\Delta CPI_t + \beta_5 LnM2_t + \beta_6 Ln3MINT_t + \beta_7 LnOLP_t + \beta_8 LnGBY_t + \beta_9 LnFPI_t + \beta_{10} Dummy_{2008M3} + \varepsilon_t$: LASSO selection			
0 CI vectors		At most 1 CI vectors	
Trace Test Statics	Max-EV Test Statics	Trace Test Statics	Max-EV Test Statics
407.7048***	88.53.564***	319.156***	50.4895
Model 6: $LnSPI_t = c + \beta_1 \Delta LnDEM_t + \beta_2 HPI_t + \beta_3 LnRGDP + \beta_4 Ln\Delta CPI_t + \beta_5 LnM2_t + \beta_6 Ln3MINT_t + \beta_7 LnOLP_t + \beta_8 LnGBY_t + \beta_9 LnFPI_t + \beta_{10} LnEX_t + \beta_{11} Dummy_{2008M3-2017M6} + \varepsilon_t$: All control variables			

0 CI vectors		At most 1 CI vectors	
Trace Test Statics	Max-EV Test Statics	Trace Test Statics	Max-EV Test Statics
396.7323***	108.8997***	287.8326***	82.89562***
Model 7: $LnSPI_t = c + \beta_1 \Delta DEM_{W,t} + \beta_2 Dummy_{2008M3} + \varepsilon_t$: Life cycle hypothesis			
0 CI vectors		At most 1 CI vectors	
Trace Test Statics	Max-EV Test Statics	Trace Test Statics	Max-EV Test Statics
86.6373***	83.862***	2.7753	2.7753
Model 8: $LnSPI_t = c + \beta_1 \Delta DEM_t + \beta_2 HPI_t + \beta_3 LnRGDP + \beta_4 Ln\Delta CPI_t + \beta_5 LnM2_t + \beta_6 Ln3MINT_t + \beta_7 LnOLP_t + \beta_8 LnGBY_t + \beta_9 LnFPI_t + \beta_{10} Dummy_{2008M3} + \varepsilon_t$			
0 CI vectors	At most 1 CI vectors		
Trace Test Statics	Max-EV Test Statics	Trace Test Statics	Max-EV Test Statics
345.1172***	111.5317***	197.3709***	70.02085***

Notes: The table uses the most significant structural break March 2008 as exogenous variable and set dummy variable D=1 for March 2008 only. For Model 5, the trace test suggests that there are 4 statistically significant cointegrations at the 5% level of significance, while the Johansen cointegration Max-EV test suggests there is 1 statistically significant cointegration at the 5% significance level. For Model 6, both the trace test and Max-EV test suggest there are 3 cointegrations. For the sake of prudence, we report the first 2 cointegrations.

Johansen Cointegration Test: Panel B

Model 1: $LnSPI_t = c + \beta_1 \Delta LnDEM_t + \beta_2 Dummy_{2008M3\_2017M6} + \varepsilon_t$: Life cycle hypothesis			
0 CI vectors		At most 1 CI vectors	
Trace Test Statics	Max-EV Test Statics	Trace Test Statics	Max-EV Test Statics
12.878	9.6473	3.2307*	3.2307*
Model 2: $LnSPI_t = c + \beta_1 \Delta LnDEM_t + \beta_2 LnHPI_t + \beta_3 Dummy_{2008M3\_2017M6} + \varepsilon_t$: Credit effect hypotheses			
0 CI vectors		At most 1 CI vectors	
Trace Test Statics	Max-EV Test Statics	Trace Test Statics	Max-EV Test Statics
29.972**	20.969*	5.0025	4.7989
Model 3: $LnSPI_t = c + \beta_1 \Delta LnDEM_t + \beta_2 LnRGDP_t + \beta_3 \Delta LnCPI_t + \beta_4 Dummy_{2008M3\_2017M6} + \varepsilon_t$: General Equilibrium theory			
0 CI vectors		At most 1 CI vectors	
Trace Test Statics	Max-EV Test Statics	Trace Test Statics	Max-EV Test Statics
60.3503***	34.513***	25.8367	13.8172
Model 4: $LnSPI_t = c + \beta_1 \Delta LnDEM_t + \beta_2 LnRGDP_t + \beta_3 LnHPI_t + \beta_4 \Delta LnCPI_t + \beta_5 Dummy_{2008M3\_2017M6} + \varepsilon_t$: General Equilibrium theory			
0 CI vectors		At most 1 CI vectors	
Trace Test Statics	Max-EV Test Statics	Trace Test Statics	Max-EV Test Statics
75.5356**	40.2043***	35.3313	14.9514
Model 5: $LnSPI_t = c + \beta_1 \Delta LnDEM_t + \beta_2 HPI_t + \beta_3 LnRGDP + \beta_4 Ln\Delta CPI_t + \beta_5 LnM2_t + \beta_6 Ln3MINT_t + \beta_7 LnOLP_t + \beta_8 LnGBY_t + \beta_9 LnFPI_t + \beta_{10} Dummy_{2008M3-2017M6} + \varepsilon_t$: LASSO selection			
0 CI vectors		At most 1 CI vectors	
Trace Test Statics	Max-EV Test Statics	Trace Test Statics	Max-EV Test Statics
327.88***	83.177***	244.711***	54.2146

Model 6: $LnSPI_t = c + \beta_1 \Delta LnDEM_t + \beta_2 HPI_t + \beta_3 LnRGDP + \beta_4 Ln\Delta CPI_t + \beta_5 LnM2_t + \beta_6 Ln3MINT_t + \beta_7 LnOLP_t + \beta_8 LnGBY_t + \beta_9 LnFPI_t + \beta_{10} LnEX_t + \beta_{11} Dummy_{2008M3-2017M6} + \varepsilon_t$: All control variables			
0 CI vectors		At most 1 CI vectors	
Trace Test Statics	Max-EV Test Statics	Trace Test Statics	Max-EV Test Statics
441.8989***	110.6352***	331.2637***	98.49402***
Model 7: $LnSPI_t = c + \beta_1 \Delta DEM_{W,t} + \beta_2 Dummy_{2008M3\_2017M6} + \varepsilon_t$: Life cycle hypothesis			
0 CI vectors		At most 1 CI vectors	
95.8545***	92.3571***	3.4974	3.4975
Model 8: $LnSPI_t = c + \beta_1 \Delta DEM_t + \beta_2 HPI_t + \beta_3 LnRGDP + \beta_4 Ln\Delta CPI_t + \beta_5 LnM2_t + \beta_6 Ln3MINT_t + \beta_7 LnOLP_t + \beta_8 LnGBY_t + \beta_9 LnFPI_t + \beta_{10} Dummy_{2008M3-2017M6} + \varepsilon_t$			
0 CI vectors		At most 1 CI vectors	
320.3662***	122.4263***	197.940***	57.8228***

Notes: The table uses the most significant structural break March 2008 as exogenous variable and set dummy variable $D = 1$ for the subsample from March 2008 to the June 2017. For Model 5, the Johansen trace test suggests that there are 5 statistically significant cointegrations at the 5% level of significance. The Johansen cointegration Max-EV test suggests there is 1 statistically significant cointegration at the 5% significance level. For Model 6, the trace test suggests that there are 5 statistically significant cointegrations at the 5% level of significance. The Johansen cointegration Max-EV test suggests there are 2 statistically significant cointegrations at the 5% significance level. For the sake of prudence, we report the first 2 cointegrations for Models 5 and 6.

Table 5 Auto Regressive Distributed Lag (ARDL) bounds testing for cointegration

Model 1: $LnSPI_t = c + \beta_1 \Delta LnDEM_t + \beta_2 Dummy + \varepsilon_t$: Life cycle hypothesis			
ADJ	Coefficient (Standard Error)	ADJ	Coefficient (Standard Error)
$LnSPI_{t-1}$	-0.012 (0.0096)	$LnSPI_{t-1}$	-0.0138 (0.0105)
Long Run		Long Run	
$\Delta LnDEM_t$	-184.1908*** (253.8364)	$\Delta LnDEM_t$	-160.15*** (224.3225)
$Dummy_{2008M3}$	-0.0494 (0.3898)	$Dummy_{2008M3-2017M6}$	0.0018 (0.0051)
Short Run		Short Run	
constant	0.0864 (0.0638)	constant	0.0978 (0.0693)
F-test	1.689	F-test	1.907
ARCH LM test	2.039	ARCH LM test	1.994
Breusch Godfrey LM test	0.498	Breusch Godfrey LM test	0.462
Ramsey RESET test	0.31	Ramsey RESET test	0.9
Jarque-Bera test	2.623	Jarque-Bera test	2.48

Notes: If the computed F-statistics is less than the lower bound of the critical values then the null hypothesis of no cointegration is not rejected. The lower bound critical value for the F-statistics is 4.94 at the 5% level. The null hypothesis of Jarque-Bera test is normality. The null hypothesis of Ramsey RESET test is the model has no omitted variables. The null hypothesis for Breusch-Godfrey LM test is no autocorrelation. The null hypothesis of ARCH LM test is no ARCH effects.

ARDL cointegration test for Model 1 is based on DEM (Population aged between 55 and 64 relative to working age population), and the variable is not naturally logged.

Model 1: $LnSPI_t = c + \beta_1 \Delta DEM_{W,t} + \beta_2 Dummy + \varepsilon_t$: Life cycle hypothesis			
ADJ	Coefficient (Standard Error)	ADJ	Coefficient (Standard Error)
$LnSPI_{t-1}$	-0.015 (0.0094)	$LnSPI_{t-1}$	-0.0181 (0.0153)
Long Run		Long Run	
ΔDEM_t	-0.9038 (3.5229)	ΔDEM_t	-1.125 (3.8215)
$Dummy_{2008M3}$	-0.0531 (0.7834)	$Dummy_{2008M3-2017M6}$	0.0213 (0.0342)
Short Run		Short Run	
constant	0.106 (0.0633)	constant	0.0861 (0.0963)
F-test	1.391	F-test	1.954
ARCH LM test	5.231	ARCH LM test	4.751
Breusch Godfrey LM test	0.329	Breusch Godfrey LM test	0.705
Ramsey RESET test	1.78	Ramsey RESET test	1.284
Jarque-Bera test	1.856	Jarque-Bera test	2.97

Table 6 The hypotheses tests for statistical significance of the Time-varying Parameters

	Final State	Z-statistic	p-value
Model 1: $\Delta LnSPI_t = c + sv_{1,t}\Delta\Delta LnDEM_t + \varepsilon_t$			
$sv_{1,t}$	6.5328	0.5259	0.599
Model 2: $\Delta LnSPI_t = c + sv_{1,t}\Delta\Delta LnDEM_t + sv_{2,t}\Delta LnHPI_t + sv_{3,t}CI_{t-1} + \varepsilon_t$			
$sv_{1,t}$	3.8411	0.2643	0.7915
$sv_{2,t}$	0.0058	0.0349	0.9722
$sv_{3,t}$	-0.0253*	-1.9126	0.0558
Model 3: $\Delta LnSPI_t = c + sv_{1,t}\Delta\Delta LnDEM_t + sv_{2,t}\Delta LnRGDP_t + sv_{3,t}\Delta\Delta LnCPI_t + sv_{4,t}CI_{t-1} + \varepsilon_t$			
$sv_{1,t}$	6.5644	0.5234	0.6007
$sv_{2,t}$	1.4213***	3.1995	0.0014
$sv_{3,t}$	-0.2925	-0.1389	0.89
$sv_{4,t}$	-0.0102**	-1.977	0.048
Model 4: $\Delta LnSPI_t = c + sv_{1,t}\Delta\Delta LnDEM_t + sv_{2,t}\Delta LnHPI_t + sv_{3,t}\Delta LnRGDP_t + sv_{4,t}\Delta\Delta LnCPI_t + sv_{5,t}CI_{t-1} + \varepsilon_t$			
$sv_{1,t}$	5.2006	0.3618	0.7175
$sv_{2,t}$	-0.0751	-0.4438	0.6572
$sv_{3,t}$	1.4929***	3.0636	0.0022
$sv_{4,t}$	0.6167	0.288	0.7733
$sv_{5,t}$	-0.0198**	-2.335	0.0195
Model 5: $\Delta LnSPI_t = c + sv_{1,t}\Delta\Delta LnDEM_t + sv_{2,t}\Delta LnHPI_t + sv_{3,t}\Delta LnRGDP_t + sv_{4,t}\Delta\Delta LnCPI_t + sv_{5,t}\Delta LnM2_t + sv_{6,t}\Delta Ln3MINT_t + sv_{7,t}\Delta LnOLP_t + sv_{8,t}\Delta LnGBY_t + sv_{9,t}\Delta LnFPI_t + sv_{10,t}CI_{t-1} + \varepsilon_t$			

$sv_{1,t}$	14.16297	0.881179	0.3782
$sv_{2,t}$	0.084254	0.447715	0.6544
$sv_{3,t}$	1.519117***	2.83958	0.0045
$sv_{4,t}$	0.878817	0.354313	0.7231
$sv_{5,t}$	-0.234932**	-2.242807	0.0249
$sv_{6,t}$	0.002659	0.067937	0.9458
$sv_{7,t}$	0.014159	0.517041	0.6051
$sv_{8,t}$	-0.07405	-1.160431	0.2459
$sv_{9,t}$	0.005989*	1.629056	0.1033
$sv_{10,t}$	-0.008741**	-2.369425	0.0178
Model 6: $\Delta LnSPI_t = c + sv_{1,t}\Delta\Delta LnDEM_t + sv_{2,t}\Delta LnHPI_t + sv_{3,t}\Delta LnRGDP_t + sv_{4,t}\Delta\Delta LnCPI_t + sv_{5,t}\Delta LnM2_t + sv_{6,t}\Delta Ln3MINT_t + sv_{7,t}\Delta LnOLP_t + sv_{8,t}\Delta LnGBY_t + sv_{9,t}\Delta LnFPI_t + sv_{10,t}\Delta LnEX_t + sv_{11,t}CI_{1,t-1} + sv_{12,t}CI_{2,t-1} + \varepsilon_t$			
$sv_{1,t}$	2.040692	0.138006	0.8902
$sv_{2,t}$	0.025705	0.146999	0.8831
$sv_{3,t}$	1.428090***	2.788407	0.0053
$sv_{4,t}$	-1.145675	-0.465486	0.6416
$sv_{5,t}$	-0.207036**	-2.136564	0.0326
$sv_{6,t}$	-0.030178	-0.799658	0.4239
$sv_{7,t}$	-0.003135	-0.120335	0.9042
$sv_{8,t}$	-0.071219	-1.186174	0.2356
$sv_{9,t}$	0.009750***	2.713265	0.0067
$sv_{10,t}$	-0.331878***	-4.962848	0.0000
$sv_{11,t}$	-4.87E-05	-0.036109	0.9712
$sv_{12,t}$	-0.876046	-1.421136	0.1553

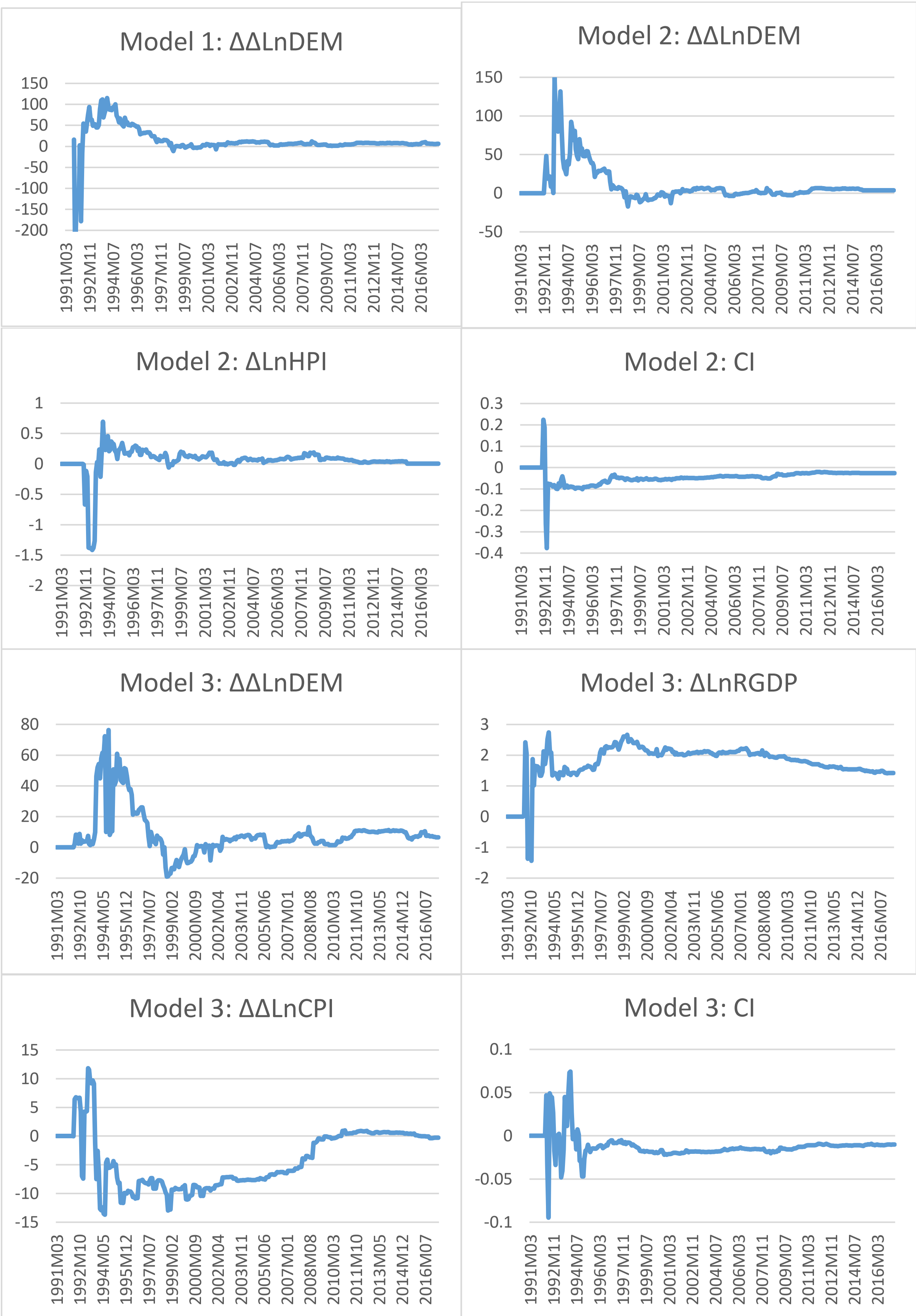
Notes: Root MSE stands for Root Mean Square Error. CI_t stands for cointegration term.

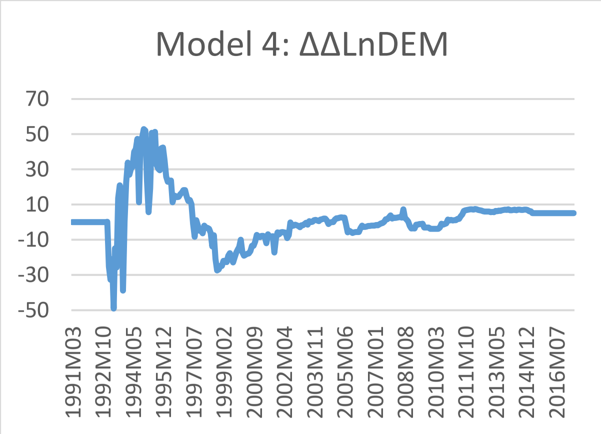
Table 7 Diagnostic testing for the State-space based time-varying parameter model

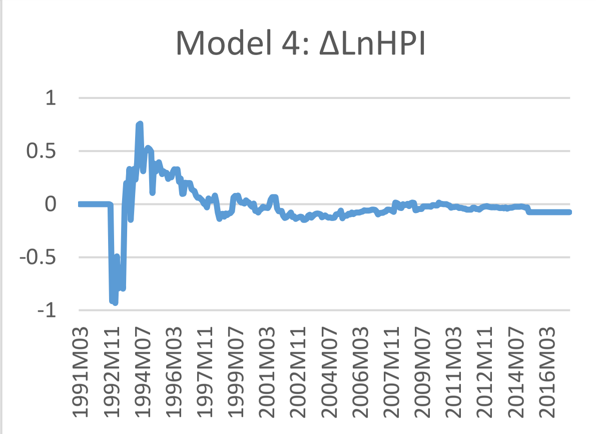
	Independence (L-B Test)	Homoscedasticity (McLeod-Li Test)	Normality (J-B Test)	AIC	BIC	Remark
Model 1	13.593	No ARCH effect	34.66**	-3.618	-3.594	Acceptable
Model 2	13.244	No ARCH effect	3.350	-3.448	-3.421	Valid
Model 3	11.794	No ARCH effect	1.255	-3.476	-3.451	Valid
Model 4	12.774	No ARCH effect	4.986	-3.378	-3.351	Valid
Model 5	12.682	No ARCH effect	4.368	-3.938	-3.907	Valid
Model 6	12.990	No ARCH effect	21.23**	-2.902	-2.871	Acceptable

Notes: The null hypothesis for the Ljung-Box (L-B) test is that the residuals are independent at Q(12). The null hypothesis for the Jarque-Bera (J-B) test is that the residuals are a normally distributed. *** represents the statistical significance at the 1% significance level. The null hypothesis of the McLeod_Li test is the independence of returns and if it is rejected, it indicates the presence of ARCH/GARCH nonlinear effects in the data. The residuals should satisfy independence, homoscedasticity and normality in decreasing order of importance. The diagnostic tests are applied to the standardized prediction errors (Commandeur and Koopman, 2007, p. 90).

Figure 1 Time-varying coefficients




Model 4: ΔΔLnDEM
70
50
30
10
-10
-30
-50
1991M03
1992M10
1994M05
1995M12
1997M07
1999M02
2000M09
2002M04
2003M11
2005M06
2007M01
2008M08
2010M03
2011M10
2013M05
2014M12
2016M07


Model 4: ΔLnHPI
1
0.5
0
-0.5
-1
1991M03
1992M11
1994M07
1996M03
1997M11
1999M07
2001M03
2002M11
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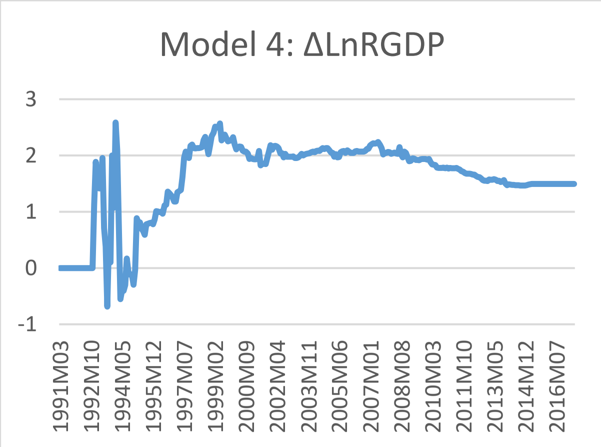
2006M03
2007M11
2009M07
2011M03
2012M11
2014M07
2016M03


Model 4: ΔLnRGDP
3
2
1
0
-1
1991M03
1992M10
1994M05
1995M12
1997M07
1999M02
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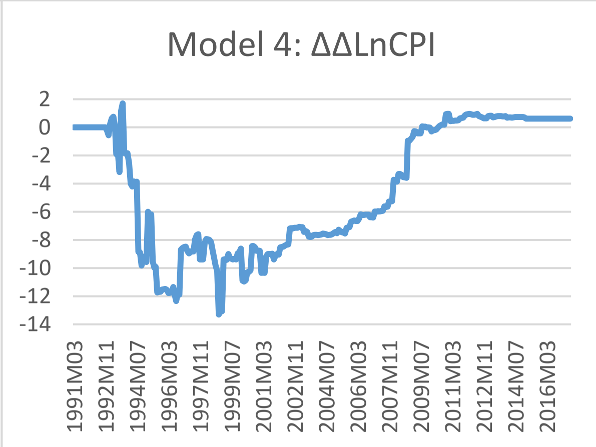
2002M04
2003M11
2005M06
2007M01
2008M08
2010M03
2011M10
2013M05
2014M12
2016M07


Model 4: ΔΔLnCPI
2
0
-2
-4
-6
-8
-10
-12
-14
1991M03
1992M11
1994M07
1996M03
1997M11
1999M07
2001M03
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2007M11
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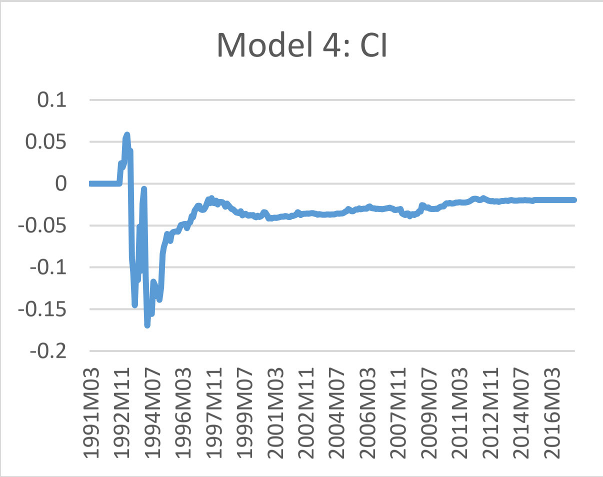
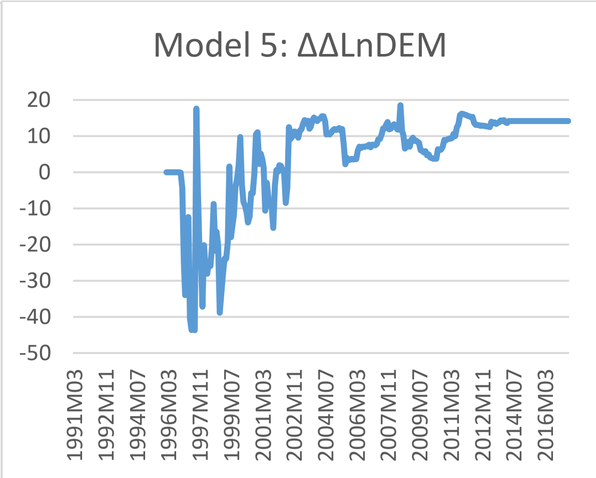
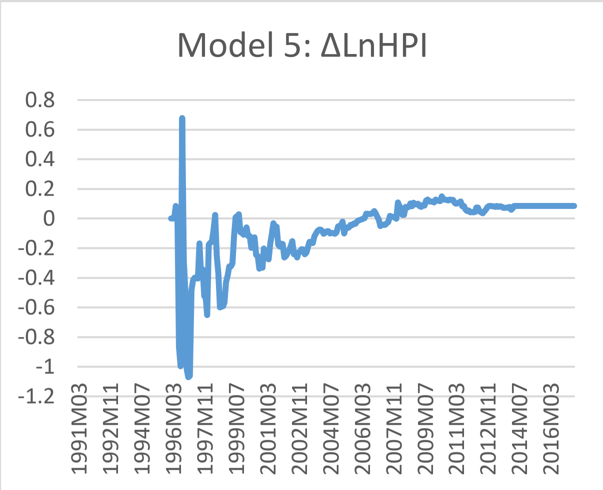
2011M03
2012M11
2014M07
2016M03


Model 4: CI
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
1991M03
1992M11
1994M07
1996M03
1997M11
1999M07
2001M03
2002M11
2004M07
2006M03
2007M11
2009M07
2011M03
2012M11
2014M07
2016M03


Model 5: ΔΔLnDEM
20
10
0
-10
-20
-30
-40
-50
1991M03
1992M11
1994M07
1996M03
1997M11
1999M07
2001M03
2002M11
2004M07
2006M03
2007M11
2009M07
2011M03
2012M11
2014M07
2016M03


Model 5: ΔLnHPI
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
1991M03
1992M11
1994M07
1996M03
1997M11
1999M07
2001M03
2002M11
2004M07
2006M03
2007M11
2009M07
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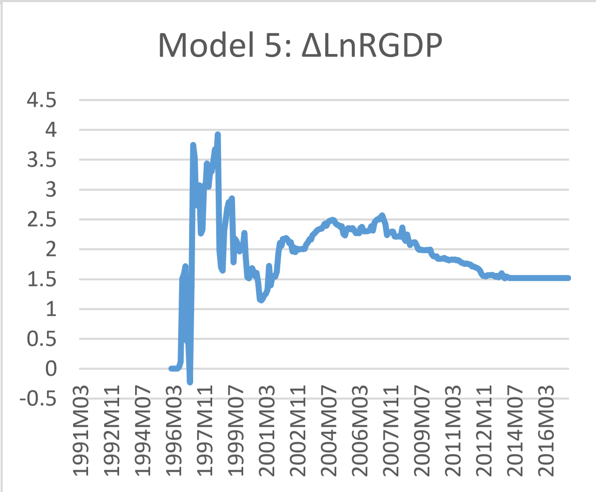
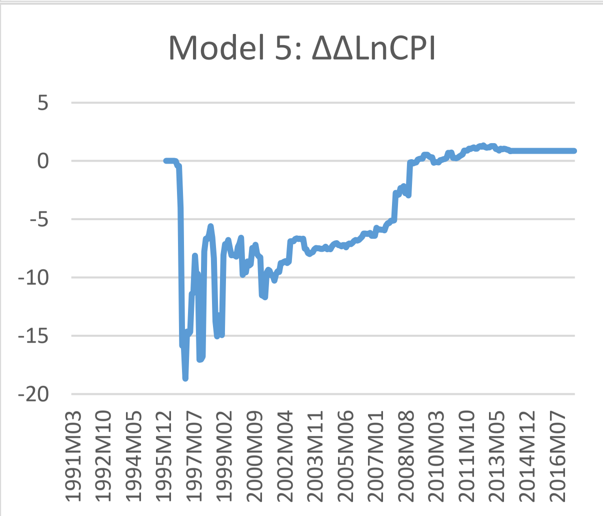
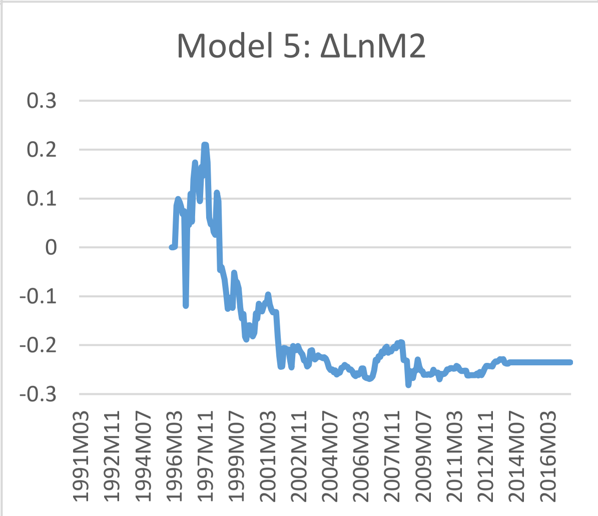
2012M11
2014M07
2016M03


Model 5: ΔLnRGDP
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
1991M03
1992M11
1994M07
1996M03
1997M11
1999M07
2001M03
2002M11
2004M07
2006M03
2007M11
2009M07
2011M03
2012M11
2014M07
2016M03


Model 5: ΔΔLnCPI
5
0
-5
-10
-15
-20
1991M03
1992M10
1994M05
1995M12
1997M07
1999M02
2000M09
2002M04
2003M11
2005M06
2007M01
2008M08
2010M03
2011M10
2013M05
2014M12
2016M07


Model 5: ΔLnM2
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
1991M03
1992M11
1994M07
1996M03
1997M11
1999M07
2001M03
2002M11
2004M07
2006M03
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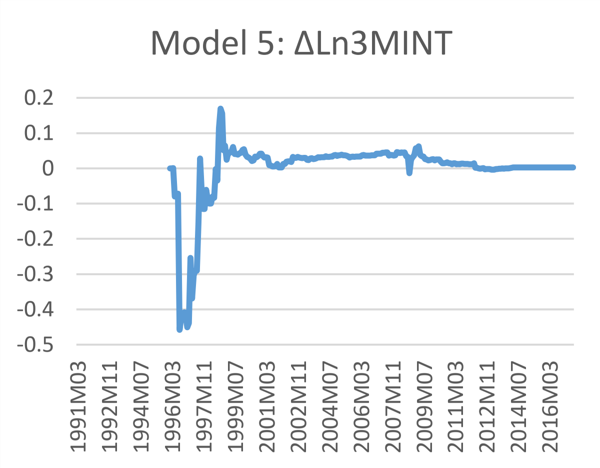
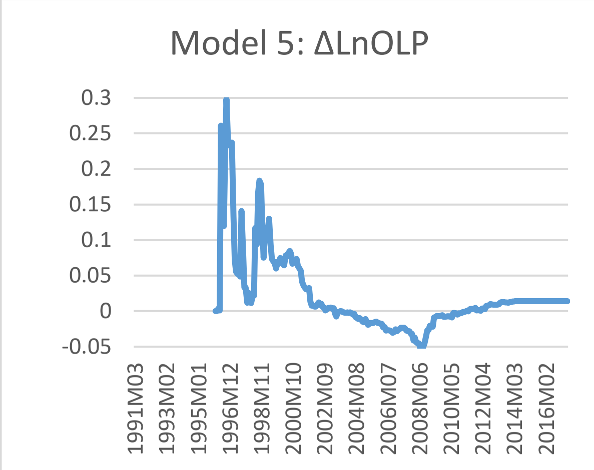
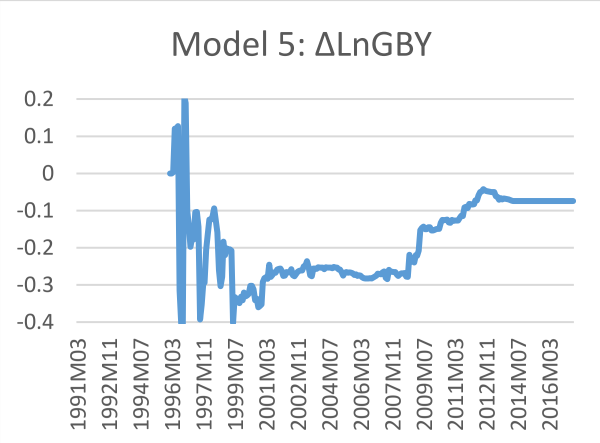
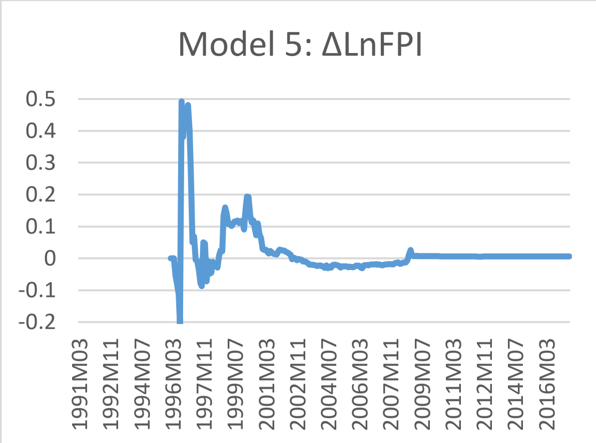
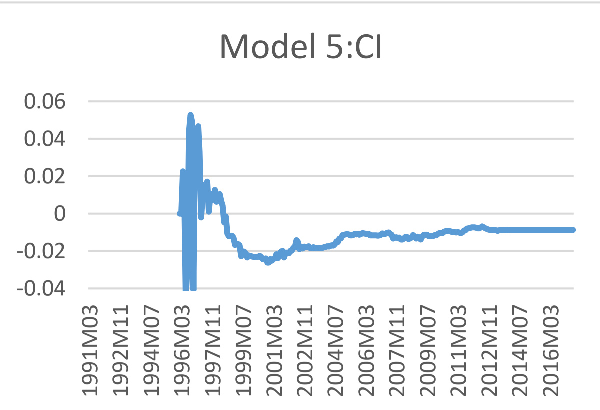
2011M03
2012M11
2014M07
2016M03





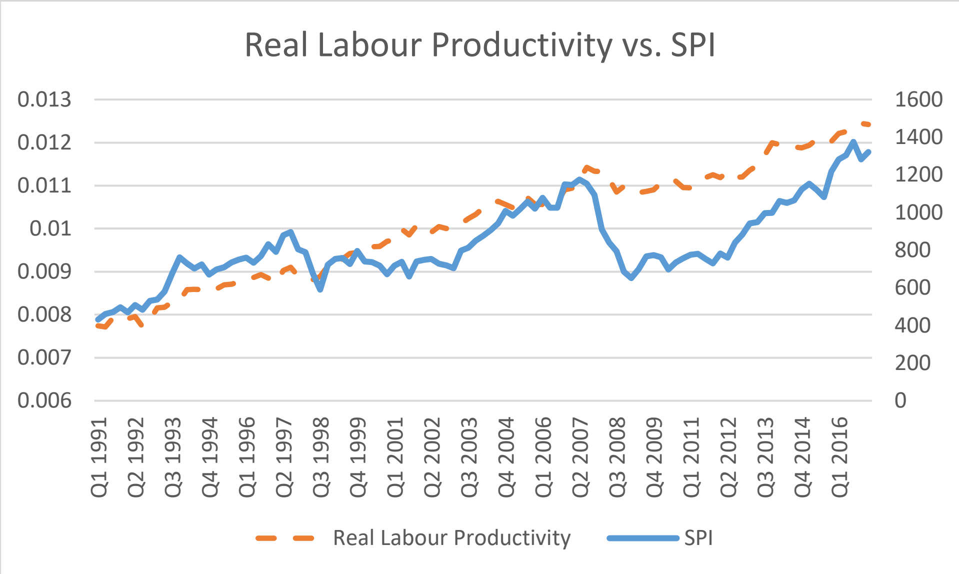






Notes: CI stands for Cointegration.

Figure 2 The relationship between real labor productivity and stock prices



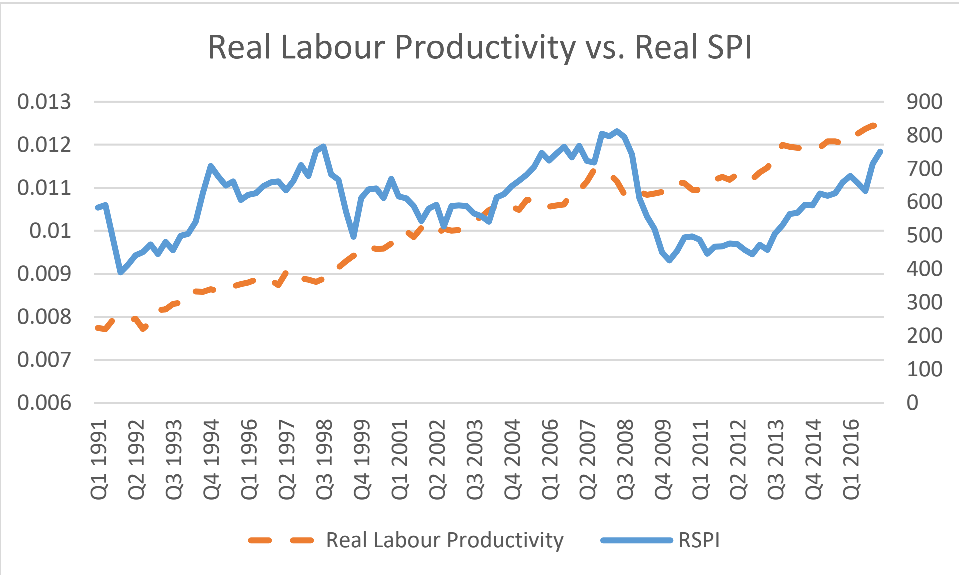
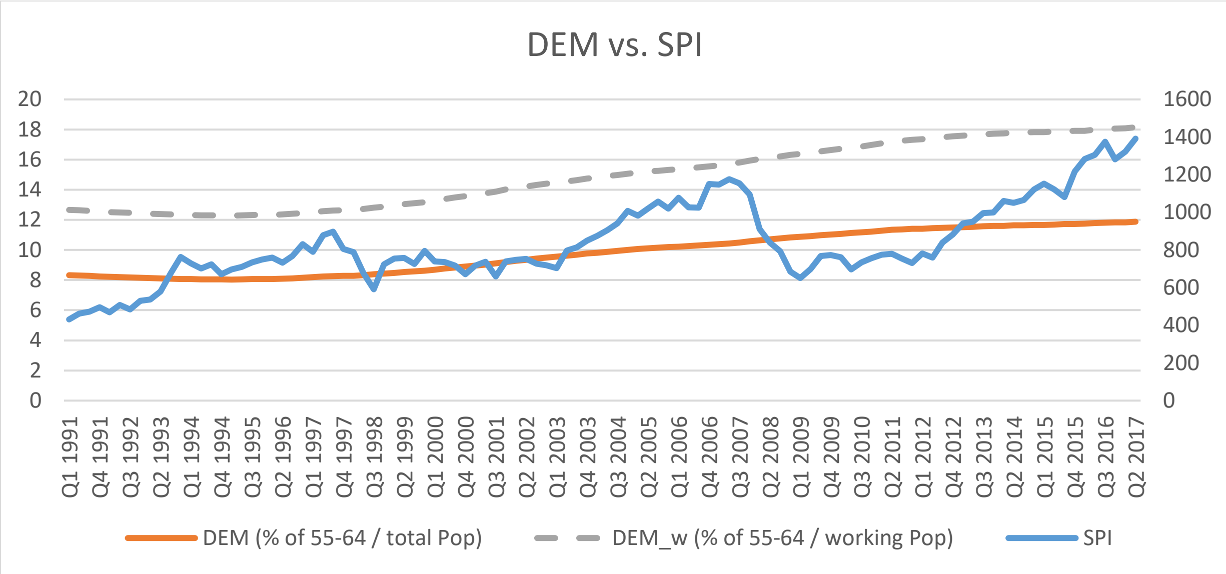


Figure 3 The relationship between aging population and stock prices



Notes: The solid line shows the percentage of population aged between 55 and 64 relative to total population and the broken line shows the percentage of population aged between 55 and 64 relative to working age population.

Appendix

Table A1 – Percentage of Population in Three Age Groups (1951-2051 Projection)

Age	1951	1961	1971	1981	1991	2001	2011	2021	2031	2041	2051
0-14	29.4	33.1	31.8	26.7	22.8	23	19	18	17	16	16
15-64	61.4	58.3	59.7	63.3	65.9	66	67	65	61	59	59
65+	9.2	8.6	8.5	10	11.2	12	14	18	22	25	25

Source: Statistics NZ. http://www.stats.govt.nz/Census.aspx

Table A2 List of major political, social and economic events over 1990-2017

Year	Event	Source
1990M03	Inflation targeting implemented	http://www.imf.org/external/pubs/ft/fandd/basics/target.htm
1992M09	Recession	http://www.dol.govt.nz/publications/discussion-papers/current-recession/
1997M09	Asian financial crisis	http://www.treasury.govt.nz/publications/research-policy/wp/2011/11-01/05.htm
1998M06	Recession	http://www.stats.govt.nz/browse_for_stats/income-and-work/employment_and_unemployment/wage-slow-down.aspx
1999M12	Labour party wins election. Helen Clark becomes prime minister	http://www.nzhistory.net.nz/people/helen-clark
2007M07	Kiwisaver policy implemented	http://docs.business.auckland.ac.nz/Doc/WP-2014-1-KiwiSaver.-Now-we-are-six.pdf
2008M09	Global financial crisis	http://www.stats.govt.nz/browse_for_stats/income-and-work/employment_and_unemployment/nz-labour-market-during-recession.aspx
2008M11	John Key leads the centre-right National party to victory in a general election, ending nine years of Labour-led government	https://national.org.nz/about/nationals-history
2009M03	Official figures show the NZ economy shrank at its fastest rate in 17 years in the last three months of 2008	http://www.stats.govt.nz/browse_for_stats/income-and-work/employment_and_unemployment/nz-labour-market-during-recession.aspx
2010M05	Significant tax cut	http://taxpolicy.ird.govt.nz/publications/2010-sr-budget2010-special-report/personal-tax-cuts
2011M02	Christchurch earth quakes	http://www.teara.govt.nz/en/historic-earthquakes/page-13
2011M09	NZ hosted rugby world cup	http://www.stats.govt.nz/browse_for_stats/economic_indicators/NationalAccounts/impact-of-rugby-world-cup.aspx
2016M12	Bill English becomes prime minister after John Key quits unexpectedly	http://www.bbc.co.uk/news/world-asia-pacific-15370160
2017M05	A New Zealand-American company, Rocket Lab, launches its first test rocket into space	http://www.bbc.co.uk/news/world-asia-pacific-15370160
2017M10	Labour's Jacinda Ardern forms coalition government after the parliamentary elections	http://www.bbc.co.uk/news/world-asia-pacific-15370160

Table A3 Data description

Variable	Sample range	No. of Obs	Mean	Standard Deviation	Min	Max	Normality
$LnEX_t$	1991m3/2016m12	310	0.5107	0.1928	0.1658	0.9911	17.4***
$LnHPI_t$	1992m1/2015m3	279	7.6532	0.4341	6.9078	8.3758	24.81***
$LnM2_t$	1991m3/2017m1	311	10.668	0.3862	10.032	11.466	10.8***
$Ln3MINT_t$	1991m4/2017m6	315	1.6471	0.4287	0.7181	2.3145	26.69***
$RGDP_t$	1991m3/2017m3	313	10.2426	0.2193	9.8209	10.6132	19.76***
$LnOLP_t$	1991m3/2016m12	310	3.3493	0.5171	2.2504	4.4899	20.83***
$LnDEM_t$	1991m3/2017m6	316	2.2652	0.141	2.0774	2.466	33.17***
DEM_t	1991m3/2017m6	316	9.7289	1.3638	7.9837	11.7759	32.59***
$DEM_{W,t}$	1991m3/2017m6	316	14.916	2.0929	12.2787	18.1488	27.19***
$LnSPI_t$	1991m3/2017m6	316	6.7077	0.2449	6.0666	7.2438	0.2477
$LnGBY_t$	1991m4/2017m6	315	1.7481	0.3021	0.7836	2.3786	38.43***
$LnCPI_t$	1991m3/2017m6	316	4.861	0.167	4.6052	5.1162	26.23***
$LnFPI_t$	1995m6/2014m3	226	9.1121	0.7192	-0.3748	9.6092	170***
$\Delta LnEX_t$	1991m4/2016m12	309	-0.00035	0.0338	-0.1252	0.1396	61.48***
$\Delta LnHPI_t$	1992m2/2015m3	278	0.00528	0.0138	-0.0259	0.0645	4.188
$\Delta LnM2_t$	1991m4/2017m1	310	0.00448	0.0249	-0.0683	0.0859	3.176
$\Delta Ln3MINT_t$	1991m5/2017m6	314	-0.00508	0.0667	-0.3447	0.2872	386.9***
$\Delta RGDP_t$	1991m4/2017m3	312	0.00251	0.0044	-0.0118	0.0147	2.129
$\Delta LnOLP_t$	1991m4/2016m12	309	0.0013	0.0912	-0.4113	0.2983	33.46***
$\Delta\Delta LnDEM_t$	1991m4/2017m6	315	0.0000078	0.00018	-0.00047	0.00063	1.99
$\Delta LnSPI_t$	1991m4/2017m6	315	0.0037	0.0391	-0.1496	0.1278	21.95***
$\Delta LnGBY_t$	1991m5/2017m6	314	-0.0043	0.0432	-0.1605	0.1672	23.18***
$\Delta\Delta LnCPI_t$	1991m4/2017m6	315	-0.000003	0.00109	-0.00619	0.00636	1502***
$\Delta LnFPI_t$	1995m7/2014m3	225	-0.0024	0.7034	-7.8755	6.3418	890***

Notices: *** stands for statistically significant at the 1% significance level. All the variables in this table are in natural log level. The null hypothesis of Jarque-Bera normality test is normal distribution. Δ stands for the first difference of the variables.