THE IMPACT OF POPULATION AGING ON LOCAL REVENUE: DISTRICT-LEVEL EVIDENCE FROM SOUTH AFRICA

BY

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Any errors in this work are my own.

Declaration

I, Nomusa Yolanda Nkomo, declare that my dissertation titled "The impact of population ageing on local revenue: a district level evidence from South Africa" is my own work and that the sources used or quoted have been indicated and acknowledged by means of references. This dissertation was not previously submitted by me for a degree at another institution.

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Abstract

This paper examines the empirical relationship between the population ageing and local revenue in South Africa. Using annual datasets for the period 1995 to 2013, the study focuses on the 52 districts municipalities in South Africa, over these 18 years. It analyses this relationship by utilising district-level output as a proxy for local revenue, dependency ratio, gross capital formation and employment rate data drawn from Quantec. Districts are categorised into young and old, depending on their average national old-age dependence ratio. The study adopts dynamic panel methodologies, generalised methods of moments and dynamic fixed effects as the estimation techniques in a growth model framework. One major advantage of using these methodologies is their ability to control for endogeneity, heterogeneity and cross-sectional dependence in the case of dynamic fixed effects.

The results show that in the period under study, the population structural changes in South Africa had a substantial impact on the performance of the economy at the district level. The age-dependency ratio coefficient is not only statistically significant, but exerts a negative influence on gross added value. The impact is greater in young districts than in old districts. Gross capital formation is statistically significant and positively related to gross added value, and in contrast to the age dependency, it exerts more influence in the old districts. Employment is insignificant in explaining gross added value. These disparities might be justified by the fact that there is higher economic activity in the young districts, which are predominantly occupied by the productive age cohort.

Key words: dependency ratio, revenue, district, generalised methods of moments, fixed effects

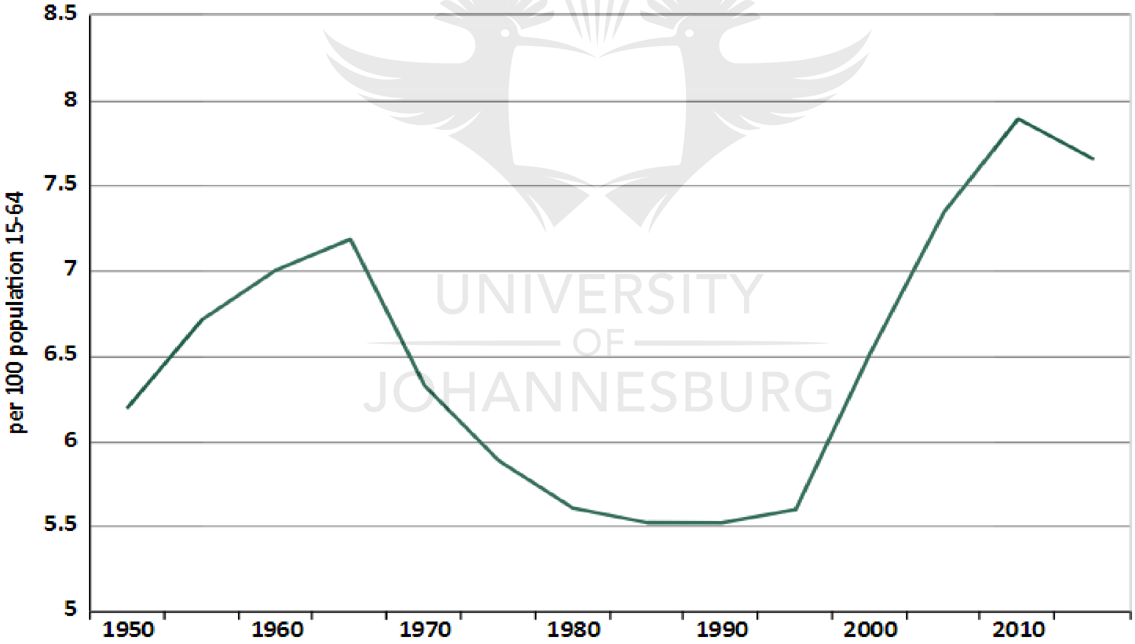
CHAPTER 1: INTRODUCTION

1.1. Background

The rapid ageing of the population is being experienced in a number of countries. The inevitability of changes in the population age structure makes it crucial to thoroughly analyse the possible implications of this phenomenon on businesses and economies (Kasnauskiene and Andriuškaitė, 2017). Although population structure is one of the key driving factors of economic growth, its impact on economic growth is not easily understood (Kelley, 1988; Fang & Wang, 2005).

South Africa too has witnessed noticeable increases in its population's age, which are driven by demographic shifts as seen by the decreases in mortality and fertility rates.

Figure 1: South Africa's old-age dependency ratio: 1950-2017



Source: Knoema, 2017

Figure 1 illustrates South Arica's old-age dependency ratio from 1950-2017, displaying a gradual decline from the late 1960s until the late 1990s, followed by a sharp rise. The statistics show that between 1990 and 1999, the old dependency ratio recorded an average of about 6% and increased to an average of around 7.5% in the period 2000-2010. This increase is mainly due to a decline in fertility and mortality rates as well as an increase in life expectancy (Banister, Bloom and Rosenberg, 2012).

Table 1 below shows demographic trends from 2002 until 2016. Fertility fell by 27% between 2002 and 2016, while mortality decreased by almost 9% in the same period. In addition, the old-age dependency ratio in South Africa rose from about 7% to approximately 8.5% and life expectancy increased by 12%. According to Banister, Bloom and Rosenberg (2012), increases in life expectancy is undeniably one of the most significant elements of demographic changes (increase in the old-age dependency ratio and decrease in the youth dependency ratio) that hinders the growth of the economy. Table 1 confirms that the South African old-age dependency ratio (65+) has sharply grown by 18% between 2012 and 2016, while the youth dependency ratio (0-14) decreased by 20% in that same period. More importantly, Statistics South Africa (StatsSA, 2017) shows that social grants and other forms of remuneration constitute the chief source of households headed by the elderly. Old-age grant recipients have risen from 2.7 million to 5.1 million between 2011 and 2015. A mere 22.9% of these people were members of a medical aid scheme in 2015 (StatsSA, 2017).

Table 1: Trends in demography structure on a national level

Year	Mortality rate	Dependency ratio		Fertility rate
		0-14/15-64	**65+/15-64**	
2002	12.9	53.71207	7.015587	2.65
2003	13.5	52.83069	7.071797	2.67
2004	14.1	51.97235	7.134464	2.69
2005	14.3	51.46899	7.305969	2.7
2006	14.2	50.55844	7.380539	2.72
2007	13.9	49.71806	7.464366	2.74
2008	13.2	48.92502	7.558825	2.75
2009	12.8	48.0707	7.651532	2.72
2010	12.4	47.19259	7.746616	2.66
2011	11.7	46.36451	7.841745	2.6
2012	10.8	45.61662	7.942568	2.57
2013	10.2	44.99086	8.051538	2.54
2014	10.1	44.46333	8.165885	2.51
2015	9.8	44.04861	8.286429	2.48
2016	9.7	43.72837	8.411644	2.43
Growth rate	**-0.27%**	**-20.40%**	**18.20%**	**-0.09%**

Source: Institute for Futures Research, 2017 and author's calculations

These statistics indicate the shift in South African population structure, namely the increasing pace of population ageing, which is a cause of concern regarding the performance of the economy in terms of savings, investment, output and appropriate policies to address economic growth challenges. A trend analysis of the relationship between economic growth and savings rate shows interesting patterns that further motivate the need for this study. For instance, South Africa's economic growth and savings rate have been declining over the years. The economic growth rate decreased from approximately 3% in 1995 to 1% in 2015, while the gross savings as a percentage of GDP was 22.4% in the period 1960-1999 and 15% in 2015, according to the World Bank (2013).

Despite a positive rate of 4.89% on average over the period 1960-2017, recent domestic savings statistics record negative digits, reaching as low as -2,70% in 2013. According to the lifecycle hypothesis, population ageing places a huge burden on the working-age population, who comprise the current savers in the economy, and this results in low savings patterns with significant impact on the performance of the economy (Simleit et al., 2011). The trends in both the variables savings and growth show signs of a continuous decrease, possibly contributing to stagnation in economic growth. Thus, recognising just how to sustain economic growth is a vital challenge facing South Africa, given the noticeable changes in population structure, particularly regarding elderly people. The question then arises, is South Africa's subdued economic growth related to the rise in population ageing?

The analysis of the impact of changes in population structures on economic growth has long been a critical issue in the macroeconomic literature (Jappelli & Modigliani, 1998). A range of theoretical models is used to clarify the relationship between population and economic growth. However, there is still no consensus regrading which model is most effective, as there seems to be a mismatch between the realities and the model predictions with regard to this relationship (Hodgson, 1988).

However, the lifecycle hypothesis developed by Modigliani and Brumberg (1954) and modified over the years has become a benchmark in the economic analysis of changing demographic structures. This model proposes that a population's demographic profile is an important factor in determining spending and saving patterns. According to the model, individuals plan their consumption and saving behaviour over their lifecycle. Modigliani and Brumberg (1954) note that individuals build up their assets in the initial stages of their working life, then use the resources they have accumulated in their retirement. This pattern of saving and spending influences the economic growth of a country directly (demand) or indirectly (savings).

On one hand, the direct impact of population age structure within the lifecycle hypothesis stems from the fact that the average propensity to consume is greater in both young individuals (0-14 years), since they are borrowing against future income, and ageing individuals (65+), as they consume savings accumulated during their working years. In other words, young individuals exhaust their income instead of saving for the future while the ageing or retired individuals use their savings after retirement to gratify their personal and family needs, hence the propensity to consume is greater. This spending by both the elderly and youth is presumed to encourage demand for goods and services that may lead to increases in production levels as well as the stimulation of economic growth in a particular state. Indirectly, the number of the young (0-14 years) and elderly (65+) individuals who are dependent on the working population (15-64 individuals) affects the amount of savings that needs to be generated by the working population who are earning income.

Depressed savings imply depressed investments, which is turn reduces economic growth owing to limited infrastructure development and employment creation (Modigliani and Brumber, 1954). Hence, the demographic progress and ageing population call for special attention so that economic growth patterns can be addressed, and speaks to the need for policymakers and analysts to understand the scale of the problem before implementing policies. It is against such a background that this study aims to investigate the relationship between population ageing and economic growth in South Africa.

1.2. Research problem

Since 2013, the South African government has put in place Local Economic Development (LED) programs that aim at reinforcing economic growth. These programs resulted in the creation of four LED pillars, which form part of the national framework of LED for 2013-2018. These pillars instantiate objectives and tactics in the form of policies that focus on hastening the country's growth and development process within the broader framework. The first pillar aims at building a diverse economic base; the second focuses on evolving knowledge and competent local economies; the third targets the broad features of economic development such as involving all communities, the informal sector and revival of the inner city; and last pillar is designed to improve economic supremacy by investing in less developed areas, thus stimulating and giving incentives to private sector investment (2013-2018 National LED Framework, 2013).

All these pillars convey the objectives of the three main development plans that influence economic performance. These plans are the National Development Plan (NDP), the National Growth Plan (NGP) and the Industrial Policy Action Plan (IPAP). The NDP focuses on employment creation that aims to eradicate poverty by involving rural economies in regional development. NGP aims to contribute to LED by developing decent employment opportunities through the promotion of rural and regional consolidation (2013-2018 National LED Framework, 2013), and IPAP promotes employment through savings on skills for smooth engagement with the labour market. Thus, because these three policies aim to create employment opportunities, the demographic change of the population is critical for them, as the level of employment depends on the population structure. Goodrick (2013) points out that population structure is the most important promoter of economic growth. Furthermore, Babatunde and Adefabi (2005) state that variations in the population activate economic growth through, for example, employment opportunities, well-being, life expectancy and reduction in fertility. It therefore becomes paramount that, given the localised goal of the NDP and the purported role of population structure in economic growth, this relationship is investigated in South Africa.

The population ageing challenge might seem to be a unique feature in developed countries owing to improved healthcare and standards of living. In the European Union, this issue has received wide research interest (Doran, 2012; Kasnauskiene and Michnevič, 2015), as well as the USA (Ahmedova and Kezdi, 2011; Maestas, Mullen and Powell, 2016). In Asia – particularly in Japan where the population ageing – this is also a very pertinent topic (Oliver, 2015). However, there a growing number of studies investigating demographic shifts – particularly the effects of population ageing

– on emerging country economies since these countries have a tendency of quickly “catching up” with global demographic trends (Jorgensen, 2011; World Bank, 2013; Hanlin, 2014).

Unlike the theoretical predictions of the lifecycle hypothesis, the empirical evidence on the association between change in population structure and economic performance remains inconclusive. Some studies document a negative relationship between population ageing and output (Aguila, 2011; Bloom et al., 2010; Yasin, 2008; Paxson and Deaton, 1997). Van Groezen, Meijdam and Verbon’s (2005) study revealed that in a closed economy, the impact of increased longevity depends on the labour and capital substitutability, and in a small country, ageing unambiguously results in long-run growth decline. Narciso (2010) found that there is an inverse relationship between population ageing and economic growth as the human capital stock increases. Arriving at the same conclusion, Bloom et al. (2010) are of the view that an ageing population leads to a decrease in the labour force participation rate and savings rate.

Furthermore, there is increasing concern about the ultimate reduction of economic growth resulting from this phenomenon. There are a number of studies concluding that in OECD countries, the ageing population results in a decrease in economic growth that may be discrete, while in developing countries the effect is insignificant. Fougere, Harvey, Mercenier and Merette (2009), Walder and Doring (2012), Eiras and Niepelt (2012) and Lisenkova et al.,(2013) also find a negative, indirect relationship between an ageing population and economic growth, arguing that an increase in the proportion of the elderly tends to be associated with lower productivity levels, decreases in savings and increases in government spending. Lindh (2004), as cited in Nagarajan, Teixeira and Silva, 2013) and Navaneethan and Dharmanlingam (2012) submit that transitions in demography pave the way for increases in the old-age dependency ratio, and this means that the smaller working age cohort faces a rising obligation to take care of the elderly.

Yet this negative relationship is not always found. In fact, a number of studies disclose a positive relationship between changes in population structure and economic growth (e.g. Samuelson, 1958; Mason, 1988; Heller,1989; Miles, 1999; Bloom, Canning & Malaney, 2000; Hondroyiannis and Papapetrou, 2002; Cai et al., 2002; Gani and Yasin, 2010; Bloom et al., 2008; Hashimoto and Tabata, 2010; Lee and Mason, 2013;

Lee, Mason & Park, 2011; Rosa & Pueyo, 2013; Prettner, 2013). According to Hazan and Zoabi (2006), health and longevity can potentially play a critical role in the process of transition from stagnation to propelling the growth of a particular country. In the case where the share of the active working age is greater than the non-working age population, Lee et al. (2011) and Prettner (2013) find a positive relationship between population ageing and growth. They reach this conclusion by arguing that a rise in population ageing will lead to changes in household savings and consumption patterns.

Without necessarily making the same argument in terms of the channel of influence, studies tend to depict a more positive correlation between changes in population structure and economic growth than a negative relationship. However, all these studies are mostly based on the national-level data, which hides important disparities across regions. Selected regional studies on the topic of population ageing and economic growth include a study conducted by Bloom et al. (2011), which investigates the impact of population ageing focusing on facts, challenges and responses in the 10 developed countries with the highest proportions of 60+ population age. Further research includes: Bloom et al.'s (2010) study of demographic change and economic growth in Asia; Pillay and Maharaj, (2013), and Uddin et al. (2016) study on population structure and impacts of savings rate on economic growth in Australia. All these studies hide some important disparities.

1.3 Research objectives

There is an extensive body of research on ageing population and economic growth carried out mostly in developed regions, with particular focus being placed on national-level associations. However, the findings at a national level may hide disparities in socioeconomic characteristics.

South Africa consists of nine provinces, 278 municipalities and 52 districts that are different in terms of socioeconomic development and demographics. Table 2 shows that the national figures in terms of socioeconomic characteristics reveal important disparities across districts. These districts can be categorised into old districts (that is, districts with an old-age dependency ratio above the national old-age dependency ratio of 7.892) and young districts (districts with an old-age dependency ratio below the national old-age dependency ratio). It appears that the young dependency ratio in the old districts is almost 93% compared to approximately 29% in the young districts, while the national level figure stands to an average of 49%. Similarly, the old-age dependency ratio is on average 11% in old districts and almost 6% for the young district, standing at 8% at the national level.

Table 2: Disparities between national and district socioeconomic and demographics (1995-2015)

Socioeconomic and demographics characteristics across districts in South Africa (Average figures)			
Characteristics	**Old districts**	**Young districts**	**National**
Socioeconomics (millions)			
Output	36373.63	132593.01	4626359
Employment	11755.13	381457.2	10908716
Gross capital formation	3246.21	12017.57	427048.8
Demographics (%)			
Youth dependency ratio	92.72	28.95	48.82
Old-age dependency ratio	10.54	6.41	7.65

Note: the districts were divided into young and old districts using national maximum age dependency ratio (7.85). All the districts with aged dependency above 7.85 classified as old districts and those below were classified as young districts.

As shown in the table above, the output for the young districts is greater than that of the old districts by a hundred million rands. This finding may owing to the fact that the young districts have more economically active people and their employment rates are very high. In order to account for regional heterogeneity in both demographic and socioeconomic characteristics in South Africa, this study makes use of the district-level data to investigate whether population ageing and economic growth patterns are related.

As a consequence, the study aims to answer the following questions:

- How does population ageing affect economic growth in heterogeneous panels of districts in South Africa?
- Do such relationships differ across young and old districts? In other words, are young districts growing faster than the old ones?

1.4. Significance of the study

Population ageing has an influence on the state's capability to respond to the needs of the elderly. This has become a critical issue both nationally and internationally. Globally, the proportion of people aged 60 years or above rose from 8.6% in 1980 to 12% in 2014, and this is expected to rise to 21% by 2050 (UNP, 2014). In 2010, the South African Finance Minister changed the age restriction old-age grant from +65 to include men between 60 and 64, and by 2011, approximately 67% of the elderly qualified for this grant. In addition to the high unemployment levels, the reduced percentage of the working-age population relative to the number of elderly dependants has important implications for government expenditures (StatsSA, 2011), hence economic growth. It is therefore imperative to analyse the impact of demographic changes on economic performance.

As demonstrated above, studies analysing the impact of population ageing on economic growth exist – particularly in developed countries – and they have mostly used national-level data. However, given the regional disparities in terms of demographic and socioeconomic developments, it is essential to identify if the impact of the ageing population differs across regions. By investigating 52 districts of South Africa over a period of 18 years, these disparities can be explored. Results from this analysis are likely to provide policymakers with relevant information regarding South Africa's attainment of the objectives of the Local Economic Development programs.

1.5 Contribution of the study

To the best of the author's knowledge, no study has yet set out to investigate the impact of population ageing on revenue in South Africa. Moreover, selected studies on the economic impact of demographics in South Africa focus on a national-level analysis, hence disregard regional heterogeneities. This paper bridges the gap in the literature by investigating the impact of an ageing population on economic growth in South Africa at a district level. To this end, panel data econometrics model techniques are implemented on annual data sets from 1995 to 2013. Against the pooled ordinary least square (OLS), which assumes time-invariant properties across districts, the dynamic fixed effect (DFE) and the generalised methods of moments (GMM) are used to account for both heterogeneity (time-invariant and individual-specific effects) and endogeneity. In fact, panel data techniques have the advantage of (i) providing a wide range of data points (NT), which increases the degrees of freedom and (ii) reducing the collinearity among independent variables. Panel data also (III) allows the researcher to answer numerous important questions that cannot easily be addressed by time-series data sets. In addition, it (IV) permits controlling for unobserved and measurement error and (v) simplifies the computation and inference.

1.6 Outline of the study

The rest of this research paper is arranged as follows: Chapter 2 reviews theoretical and empirical literature on population ageing, savings and economic growth. Chapter 3 discusses the methodology that is used to answer the above research questions, while Chapter 4 presents the empirical findings. Lastly, Chapter 5 presents the conclusion and policy recommendations resulting from the analysis.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter reviews two theoretical frameworks that relate to population changes and economic growth: the lifecycle hypothesis and the neoclassical theory of economic growth. The empirical evidence is then discussed to highlight the approaches and their findings regarding the relationship between population ageing and economic growth. The last section will present a conclusion to this chapter.

2.2 The lifecycle theory

Developed by Modigliani and Brumberg (1954), the lifecycle hypothesis is a model that seeks to explain the consumption patterns of individuals in relation to income and age. According to the model, individuals plan their consumption and savings behaviour over their lifecycle. People save for retirement while they are earning a regular income during their working years, and consume and spend during their retirement. This model suggests that an important factor in determining the aggregate savings of a country is the population's demographic profile, with savings propensities and overall dependency ratio expected to be negatively correlated.

The lifecycle hypothesis suggests that the average propensity to consume is greater in both young and old individuals, with the former seen as borrowing against future income. In other words, young individuals exhaust their income instead of saving for the future while the ageing or retired use their savings after retirement to gratify their personal and family's needs. The propensity to consume is therefore expected to be greater in retirement than in working age. This theory inherently proposes that middle-aged people earn incomes, have a greater propensity to save and lower propensity to consume as they are saving or preserving their resources for retirement.

Modigliani and Brumberg (1954) explain that individuals thus build up their assets at the initial stages of their working life, then use the resources they have accumulated in their retirement stages. This pattern of saving and spending may directly or indirectly influence economic growth of the country. On the one hand, the spending by both the aged and younger individuals stimulates demand for goods and services, causing the production level to be higher thus leading to faster economic growth. On the other hand, the dissaving of these individuals' means that investment is suppressed, which also has implications for economic growth. Tobin (1967) is of the view that saving positively affects the economic growth as the increased savings rate is expected to increase the percentage contribution of savings to gross domestic product.

2.3 The neoclassical theory of economic growth

The Solow and Meade (1961) model of the late 1950s and 1960s developed a neoclassical theory of economic growth that outlines how a steady economic growth rate can be achieved with the proper amounts of three driving forces: labor, capital and technology. Initially, the theory focused on the first two factors of the production function, with capital and labor as the determinants of output, and "technology" an exogenous factor. The theory suggests that by fluctuating the amounts of labor and capital in the production function, an equilibrium state can be accomplished.

The theory maintains that capital accumulation and the related decisions to save are vital determinants of economic growth, since these factors have implications for technological change. Technological change is identified as a major driver of an economy; indeed, economic growth cannot continue without advances in technology. Technology is considered to supplement labor productivity in such a way that it increases the output capabilities of labor. Furthermore, according to the proponents of the neoclassical growth theory, the rate of savings plays a pivotal role in the growth process of an economy, and is considered as a constant fraction of income.

2.4 Empirical review

There is a rapid increase in population ageing in many countries owing to the inevitable shifts in demographics, which in turn give rise to increasing interest in the impact of demographic shifts on economies. The main reasons for the increasingly ageing population are increase in life expectancies and decrease in fertility rates, often in developed countries (Fougere and Merette, 1999; Azevedo et al., 2017). Whilst it may seem that the challenge of an ageing population is unique to developed countries because of their improved health care and standard of living, it is also receiving attention in emerging economies, which are catching up with global trends (Kasnauskiene and Andriuškaitė, 2017). In both developed and developing countries, a number of studies have thus empirically examined the influence of fertility, mortality and ageing on economic growth. The results are context-specific, mainly because of the empirical methodology.

2.4.1 Demographics and economic growth

Ehrlich and Kim (2005) consider an overlapping generation (OLG) model of a representative agent living through child- and adulthood as well as old age within the Malthusian framework to investigate the relationship between endogenous fertility, mortality and economic growth. Their results indicate that lower fertility is associated with economic take-offs, whilst mortality risks rise continuously as a result of a technological shock, thereby triggering economic take-off. Neanidis and Papadopoulou (2013) also use an OLG model of the reproductive agent living the same three periods using data from 90 countries for the period 1970-2008. They investigate the link between crime and fertility to inspect how these two variables can jointly influence economic growth. Both these factors are linked to the probability of escaping criminal apprehension, or conversely, the probability of arrest. The probability of apprehension and its impact on economic growth are not easily discerned, owing to non-linearities and a myriad of channels of impact. They put forward the idea that theoretically, it is probable that higher crime and fertility rates are positively related to economic growth because of the likelihood of avoiding apprehension.

Prettner and Prskawetz (2010) utilise an OLG model within the neoclassical growth framework, with endogenous fertility and educational decisions as the variables. The population was divided into four cohorts, namely children, young workers, mature workers and retirees, with each phase lasting 20 years. Low fertility rates, according to the results, are associated with higher per capita gross domestic product (GDP). Similarly, using a data set of more than 200 countries, Ranganathan et al. (2015) examine the impact of demographic transition on economic growth and also find a negative relationship. They utilise a non-linear dynamic Bayesian methodology and find that as fertility rates, fall GDP increases.

Hafner and Mayer-Foulkes (2013) investigate the impact of long-term determinants of the demographic transition and economic development in 72 countries (developed and developing) for the period 1980-2007 using panel cointegration and dynamic OLS

(DOLS) estimation techniques. Their results indicate a long-run relationship between a high level of income, human development and low fertility. However, the results also show that for developed economies, the demographic transition is basically complete, and only changes in income and human development are significant factors. In emerging economies, however, there is a negative relationship between fertility and human development, but a positive one between fertility and income.

Using the same cointegration methodology in a standard, two-period OLGs setting built on the Barro (1989) model of dynastic altruism, Elgin and Tumen (2012) sought to find out if declining population resulting from reduced fertility rates and economic growth can coexist. The framework indicates that developed economies move from labour-oriented technologies toward human capital-oriented technologies that are more inclusive of an ageing population if the returns to human capital in traditional technologies of production decrease. Hence, decreases in fertility rates are not a source of concern for developed economies.

Similarly, Kunze (2014) explored the relationship between life expectancy and economic growth in an OLG model with family altruism. Public and private investments in children as human capital are the main drivers of endogenous growth. The also results show that life expectancy affects growth through lowered investments in children, raised savings rates, reduced inheritance and adjustments in tax rates. The overall impact depends on the balance of these effects.

Dominiak, Lechman and Okonowicz (2015) adopted panel data techniques, namely fixed effects and instrumental variable regressions, in their study of the relationship between changes in total fertility rate and economic growth in 18 selected high-income countries using data for the period 1970-2011. Particularly, they tested the hypothesised U-shaped relationship between total fertility rates and economic growth, i.e. the fertility rebound. The findings suggest that there is a close inter-temporal link between total fertility rate and economic growth, thereby confirming the fertility rebound phenomenon. The turning point of the U-shape implies that as economic growth reaches a certain point, countries at higher developmental levels experience fertility rebounds since there are able to adequately provide for more children.

Similarly, Day (2012) considered an endogenous fertility model with childcare services in examining the economic growth, gender wage gap and fertility rebound amongst OECD countries. The results of this study suggest a weak positive relationship between fertility and per capita income, because the benefits of better economic performance do not necessarily result in higher female relative wages, particularly if there is the inequitable distribution of capital in the workforce. In addition, the relative productivity of the childcare sector will have an influence depending on if a rise in female relative wages can sustain a fertility upturn. Day (2016) extended this analysis in an OLG model and examined the interplay between economic growth and fertility in an economy that is moving through two phases and has different skills compositions of the workforce. The first phase was inclusive of both unskilled and skilled workers, while the second only contained skilled workers, who are seen to have fewer children. Initially, fertility rates decrease with increasing proportion of skilled workers and economic growth. Then, as wages of skilled workers increase, fertility recovers given the prevailing childcare prices.

Ashraf, Weil and Wilde (2013) analyse the economic impacts of decreases in fertility in a developing country with a high initial fertility rate. They estimate the effect of declining fertility rates on economic growth adopting a demographic-economic macro-simulation model in a three-sector framework with market imperfections. The model was parameterised to mimic the economic and demographic trends in Nigeria. The results of this study indicate that fertility reductions will lead to growth in per capita income, though the effect is relatively small.

Following Ashraf et al. (2013), Karra et al. (2015) also adopted a three-sector framework with market imperfections. Each period in the model was defined for five years, and the population categorised into five-year age groups. The results show that lowering the fertility rates by one child per woman would result in the doubling of per capita income by 2060. Analysing results from an impact evaluation study aimed at assessing the impact of access to reproductive health services on the achievement of Millennium Development Goals, Canning and Schultz (2012) came to the same conclusions. They found that in Bangladesh, Navrongo and Ghana, reduction in fertility enhances economic growth because of the resultant lower dependency ratio and increased women labour participation.

In a different approach, Ngangue and Manfred (2015) used panel data of 141 developing countries over the period 2000-2013 to study the impact of life expectancy on income per capita. The instrumental variables and GMM regression results indicate that improvements in life expectancy positively affects economic growth in developing countries.

In the Sub-Saharan region, Akintunde et al. (2013) investigated population dynamic effects of economic growth using five-year average data from 1970 to 2005 for 35 countries. To compliment OLS estimates, they also employed panel data analysis. Their findings show that fertility rate is negatively related to economic growth. Similar to Ngangue and Manfred (2015), they also found a positive relationship between life expectancy and economic growth.

Frimpong and Adu (2014) also utilised a panel data set of 30 Sub-Saharan African countries spanning 1970-2010 to assess the impact of population health on the performance of the economy. Within an augmented Solow theoretical framework, they adopted panel cointegration techniques, and found no significant relationship between population health status and economic growth.

Cervellati and Sunde (2011) examined the casual effect of life expectancy on per capita growth using Acemoglu and Johnson's (2007) framework derived from a closed neoclassical growth model. Their findings suggest that higher life expectancies quicken increase income per capita in economies that have already undergone transitions since 1940. This effect is not found in pre-transitional countries, as life expectancy is statistically significant. In other words, the impact of life expectancy on economic growth depends on whether the economy is growing or not.

Through vector error correction model (VECM) of cointegration, Frini and Muller (2012) examined the interaction between education, fertility and economic growth in Tunisia using data from 1963-2007. The study concludes that a decrease in fertility fosters and amplifies development in education and promotes economic growth. Additionally, transitions in the fertility rates produce progressive feedback on human capital and economic growth by altering the age structure in support of developments in education, improved productivity and capital efficiency. Using the same methodology, Mahyar (2016) explored the link between life expectancy and economic growth in Iran using time series data from 1966-2013. The findings here indicate a positive relationship between life expectancy and economic growth.

Choudhry and Elhorst (2010) employed a Solow Swan model and ran fixed effects models to explore the impact of demographic transitions on the economic growth of China, India and Pakistan. They found that in the period 1961-2003, population dynamics explained a significant amount of growth in per capita income for these three countries. From 2005-2050, a positive effect is anticipated in India and Pakistan, but an adverse one is expected in China.

2.4.2 Population ageing and economic growth

The previous section investigated the demographics-growth nexus in both developed and developing countries by focusing mainly on fertility and life expectancy, with a few studies explicitly directing attention to ageing. This section reviews literature on the ageing-growth nexus in both developed and developing countries. This relationship has been widely investigated in developed countries but has received limited attention in developing countries.

Within the lifecycle framework for endogenous growth, Fougere and Merette (1999) employed the dynamic China General Equilibrium (CGE) OLG model to examine the impact of population ageing on economic growth in seven OECD countries, populated by a series of 15 OLG. They found that in the long run, population ageing creates more opportunities for investment in human capital by way of future generations. This phenomenon would raise labour supply, stimulate economic growth and significantly reduce the negative impact of ageing on per capita output. They also concluded that national savings and real returns to capital decline by negligible amounts as the population ages.

Fougere et al. (2009) applied a more refined model through the incorporation of endogenous labour supply in Canada but come to similar conclusions, also noting that increased participation of older workers may be the beginning of a new trends that will be amplified in the future. Capital deepening is experienced and real wages are pushed up thereby increasing the labour supply of the middle aged. The result is a smoother impact of population ageing. Faruqee and Muhleisen (2003) come to the same conclusion in the context of Japan using the general equilibrium framework.

A theoretical model by Aisa and Pueyo (2013) explains the two opposing forces alluded to above (dependency rate effect and the capital accumulation effect). In investigating the relationship between population ageing, demand for healthcare goods and economic growth, they found that population ageing increases the demand for healthcare goods and induces a shift of labour from the non-health sector to the health sector, potentially damaging growth. At the same time, individuals modify their savings behaviour as a way of accommodating greater needs during retirement. This behaviour favours capital accumulation and increased labour productivity in the non-health sector, thereby encouraging labour movement into this sector. Thus the implication is that the two opposing forces, dependency rate effect and the capital accumulation effect, and their net effect ultimately depends on the extent of substitution between capital and labour in producing non-healthcare goods. Economic growth is slowed down if these inputs are easily substitutable since dependency rate will prevail. Economic growth is enhanced if the inputs are less substitutable since the capital accumulation effect will dominate. There are views that suggest that the increase in ageing population will not affect the production or output because the aged can be replaced by machinery (Bloom et al., 2011).

Tamirisa and Faruqee (2006) also adopted the dynamic OLG model to investigate the macroeconomic impacts of population ageing in the Czech Republic. Their simulation results indicate that population ageing will slow the growth of the economy and improvements in standards of living. However, they argue that interventions to increase labour force participation and productivity growth can alleviate these detrimental effects, although this will put the budget under pressure due to a rise in expenditures related to the rising age cohort. Similarly, Lindh and Malmberg (2009) developed an OLG model to examine the impact of population ageing in Scotland. Their results are comparable to those of Tamirisa and Faruqee (2006), suggesting that population ageing results in lower productivity. Furthermore, they highlight that age-specific effects have a significant bearing on public finances resulting from expenditures on pensions and health.

Peng (2008) used the People's Republic of China general equilibrium model (PRCGEM) in forecasting the macroeconomic performance of China over the 21st century in the wake of demographic changes and an ageing population. Consistent with the neoclassical growth theory, the results show that population ageing causes a decline in the rate of growth of the labour force, and that the shrinking of the participation rates lower the potential for growth in the economy as demand for investment drops as well. Also in line with the lifecycle hypothesis, the simulations show that the ageing of China's population results in a decline in saving and a fall in investment.

Following Fougere and Merette (1999), Peng and Mai (2008) adopted the dynamic CGE model of the Chinese economy called the C-HUGE model in evaluating the impact of population ageing over the period 2008-2020, making allowance for the reduction in labour distortions. Their results show that increased movement of non-agricultural labour mitigates the erosion of standards of living resulting from declining labour supply generated by low fertility levels and population ageing. Simply put, these increases in labour movement across sectors enhance total output growth and real consumption.

Largely drawing from Fougere et al. (2009), Choi and Shin (2015) contrasted a deterministic computable Overlapping Generations (OLG) model with human capital as an endogenous variable in the Korean economy. They investigated the impact of population ageing on the labour supply growth, the capital stock and economic growth. Their simulation results show that an ageing population has marked negative effects on labour supply, causing wages to rise. This consequence spurs investment in both human and physical capital. Whilst the growth of human capital is lower than that under the fixed population scenario, the rise in physical capital formation partially offsets the decrease in the growth of labour supply. Overall, population ageing is expected to reduce the growth potential of per capita GDP by about 25% in Korea, as indicated by the simulation results.

Drawing similar conclusions, Azevedo, Afonso and Silva's study (2017) used a north –south endogenous growth model, based on Blanchard (1985) and similar to Romer (1990), and introduced an OLG structure to investigate the effect of ageing on growth.

Research and development were taken as the main drivers of endogenous growth. Their findings reveal a positive impact of population ageing and healthcare on economic growth.

Prettner (2013) investigated the impact of population ageing on per capita output growth using endogenous and semi-endogenous growth model frameworks. The study concludes that population ageing in case of the endogenous model has a positive influence for long-run economic growth. The semi-endogenous framework shows that that the impacts on output depend on a relative change between mortality and fertility. In particular, population ageing effect depends on whether the long-run economic growth is decreasing or increasing

Li and Zhang (2015) employed cointegration techniques to examine the relationship between China's GDP per capita, national savings rate and the old-age dependency ratio using data from 1978-2012. The analysis is carried out within the standard neoclassical Solow model and obtains a steady state relation amongst the variables of interest. The results show that, in the long-run, the rate of national savings and population ageing positively impact the increase of per-capita income.

Hondroyiannis and Papapetrou (2001) investigated the relationship between low fertility rates coupled with the old age dependency ratio, labour effort and economic growth in Greece from 1960-1995. They adopted the VECM, derived impulse response function and carried out a variance decomposition analysis. The results show that in the long run, declining fertility rates and increases in the old-age dependency ratio (resulting from higher life expectancy) will lead to an overall decrease in the performance of the economy. The increasing proportion of the dependants means that they will consume a greater part of the working population's income.

Doran (2012) examined the relationship between demographics, labour effort and economic growth in Ireland for the period 1960-2007 using the value at risk (VAR) methodology with response functions and granger causality analysis. The results indicate that the old-age dependency ratio negatively impacts economic growth through reduced labour productivity. Similarly, Kasnauskiene and Andriuškaitė (2017) investigated the economic repercussions of an ageing Lithuanian population using VAR and autoregressive moving average with exogenous factors (ARMAX), and concluded that the old-age dependency ratio does not have an impact on GDP growth and employment rate in the short run. However, using data from US states from 1980-2010, Maestas et al. (2016) adopted the OLS and two-stage least square methodology to estimate the impact of ageing on state output per capita. They found that higher old-age dependency ratios are associated with decreases in the state GDP per capita, mainly owing to slower productivity growth.

An empirical study by Göbel and Zwick (2012) examined the differences in age-productivity profiles between the service and manufacturing industries in Germany in the years 1997-2005 using GMM. They concluded that not only does ageing negatively impact economic growth, but that the impact differs in different sectors. Mahlberg et al. (2013) then also used GMM together with OLS and fixed and random effect in Austria for the 2002-2005 period. Their results indicate a negative and significant relationship between ageing and output on manufacturing and service sector.

In a convergence model framework through OLS and two-stage least square regressions, Bloom et al. (2010) investigated the relationship between population ageing and economic growth in Asia. The results show that higher old-age dependency ratios negatively affect growth only in the short run, not in the long run. However, the youth dependency ratio adversely affects growth in the long run according to these findings. More importantly, they are of the view that the consequences of population ageing are dependent on factors such as the labour force participation rate of women, quantity of children as fertility decline, adjustments in savings as life expectancy increases, and the magnitude of the distortions in social security relative to the speed of policy adjustments.

2.4.3 Demographics in South Africa

Studies investigating demographics in South Africa have mainly focused on describing the describing annual trends in the ageing dynamics (Kinsella, 1997; Phaswana-Mafuya et al., 2011). At the macro level, Sadie (1994) analysed the economic implications of demographic ageing in South Africa by using a descriptive analysis approach and dividing the economy into producers and consumers. The study concludes that demographic ageing is economically beneficial up to the point at which the net producers shrink in size relative to the consumers.

In a later study, Hunter and May (2012) analysed ageing in South Africa post the apartheid era, focusing on the nearly old population and using micro-level data from the 2008 National Income Dynamic Survey (NIDS) in a lifecycle framework. They suggest that the nearly old do not earn smaller incomes, are not less likely to be outside the workforce and that their vulnerability is only in terms of health status.

Also using macro-level data, Goodrick (2013) employed a mixed-method approach that combined both quantitative and qualitative descriptive techniques to evaluate the implications of population ageing in South Africa. The study finds the need for increased care of the growing old population as well as their families, and a rise in demand for elderly healthcare services and social expenditures.

This paper aims to fill the lacuna identified above by a using dynamic panel time series technique, Syst-GMM, to investigate this relationship in South Africa on disaggregated data at the micro level. It investigates the ageing-output nexus in a developing country, i.e. South Africa, by addressing the issues of regional heterogeneity, which have previously been ignored. It will also measure the impact of ageing on economic growth at a district level with the use of dynamic panel data methods, which help to account for cross-sectional dependence (CD).

2.5 Conclusion

The most commonly used methods to investigate the interaction between population demographics (fertility and mortality), ageing and economic growth, according to the literature review, are OLG models (general and dynamic), regression analysis, VAR or VECM models and GMM. The main issues that emerge in terms of the impact of population ageing on economic growth include labour supply and productivity, human and capital accumulation as well as consumption and savings. In spite of the abundance of literature, the economic growth-ageing population nexus has received little investigation in developing economies, such as South Africa. Most studies also focus on the impact of fertility and life expectancy changes on economic growth. To the best of the author’s knowledge, no other study has empirically tested the impact of fertility, life expectancy or ageing on economic growth in South Africa. Studies that have investigated demographics in South Africa have mainly focused on describing the trends, which is less informative.

CHAPTER 3: EMPIRICAL METHODOLOGY

3.1 Introduction

This chapter aims to describe the techniques employed for the empirical investigation of the study. First, it briefly discusses panel data in general and its analysis under dynamic contexts. The model used in this study is then specified, which is followed by the pretesting, including Cross-sectional Dependence (CD) and panel unit root tests. Next, this chapter reflects upon endogeneity and dynamic estimation techniques in order to explain why the DFE rather than Syst-GMM is the method of choice.

3.2 Panel data

Panel data sets are data sets that consist of both cross-section and time series dimensions. Cross sections can be, amongst others, individuals, firms, cities, provinces or countries that are randomly selected from a population at a given point in time and then re-observed or interviewed at a successive point in time. In a formal panel data model, the variable contains two indices. The first, for the cross-sectional (unit) dimension, is usually denoted by$i$, and the second, for the time-series dimension, t is generally represented by t (Asteriou & Hall, 2007; Gutierrez, 2017).

$$Y_{it} = \alpha_0 + \beta_x X_{it} + \varepsilon_{it} \quad (1)$$

Where Y_{it} is the dependent variable, X_{it} is the k-dimensional vector of explanatory variables that are time varying, whilst ε_{it} is an idiosyncratic error term (Asteriou and Hall, 2007). Panel data methodologies are popular in the use of data from countries where the span of the time series data is not sufficient and would prohibit the study from testing a number of hypotheses of interest. Additionally, they have better power properties in comparison to standard time series methods. In several areas studied such as convergence or output dynamics, it is natural to use panel context (Barbeiri, 2006). The unit of analysis in this study consists of South African districts observed over a period of time, hence panel data analysis is suitable for this study.

3.2 Model specification

This paper draws upon Mankiw, Romer and Weil (1992) and Barro (1996) in that the growth equation is used within the neoclassical framework augmented with the demographic variable. More specifically, revenue is expressed as a function of ageing in addition to standard traditional growth determinants, which are investment and labour. Formally,

Revenue = f (investment, labour, ageing) (2)

In a panel format, a combination of equation (1) can be parametrised as follows:

$$Gva_{it} = \alpha_0 + \beta_1 Age_{it} + \beta_2 Gcf_{it} + \beta_3 Emp_{it} + \varepsilon_{it} \quad (3)$$

ι = 1,…………………N, t = 1,…………………T refer to district and time dimensions, respectively; Gva_t is the gross value added per district used as a proxy for gross domestic product; Gcf is the gross capital formation; Emp is employment rate; and ε_t is the error term.

The demographic variable is captured by population ageing and is expected to negatively impact growth as a result of productivity lost due to the ageing population. However, this effect can be offset by the increased consumption and the fact that more jobs may become available to those who are entering the labour force (Herzog, 2012). Employment is expected to be positively related to growth since the more people who are employed, the greater the output. The same applies to the gross capital formation, in that greater investment in physical capital promotes output.

3.3 Cross-sectional dependence (CD)

In panel data analysis, parameter estimation and inference are potentially compromised by the possibility of the interdependence of i units if not controlled for – an issue that has drawn considerable attention amongst researchers (Sarafidis and Wansbeek, 2012). Whilst a myriad of models assume independence across units in panel data analysis, it is possible that a shock affecting one unit may spill over into other units. For instance, as agents make remittances across regions or migrate from one district to another for reasons that include job transfers and retirements, idiosyncratic shocks (whether economic or demographic) from one district may affect other districts. Therefore, if districts are interdependent, assuming cross-sectional independence will yield inconsistent estimates.

CD puts no impositions on regions that are neighbours, meaning that it does not rely on a connectivity matrix. It can be seen as a more general form of spatial dependence, in which regions that are not necessarily neighbours may still be affected by each other from an economic and social point of view due to economic linkages. Therefore, the correlation between outcomes in regions that are geographically far apart may exist, owing to economic and social closeness (Jensen & Schmidt, 2011). Considering that this study is at a district level within the geographical borders of one country, CD is highly likely, providing motivation to investigate it.

The common approach is to specify the cross-sectional correlation strength through an N x N spatial weighting matrix W, then test if the proportional factor denoted by ρ is equal to zero, as suggested by Kelejian and Pucha (2001). The null hypothesis is cross-sectional independence, and this test is sensitive to the weight W. The Langragian multiplier is an alternative proposed by Breusch and Pagan (1980) that does not depend on spatial weighting and tests how diagonal an error covariance matrix is of seemingly unrelated systems of equations. This method, however, if not centered correctly can lead to a grave over-rejection of the null of cross-section independence in cases where N is large relative to T (Pesaran, 2004; Pesaran, Ullah and Yamagata, 2008). Pesaran (2004) suggests a Cross-section dependence (CD) test that simply uses the average of all pairwise correlation coefficients, called the Cross-section dependence (CD) test. It is shown that the CD test is correctly centered for fixed N and T in a linear model under the null of cross-section independence, assuming that there is an asymptotic distribution of errors. Hsiao, Pesaran and Pick (2012) argue that the CD performs well even in situations where N and T are comparatively low, with distortions only arising when N = 500 and T is less or equal to 20.

3.4 Panel unit root

The districts under study are believed to exhibit a significant degree of heterogeneity, and much attention has been drawn towards the problem of unit roots in heterogeneous panels (Hlouskova & Wagner, 2005; Pesaran, 2007). Such studies include the works of Im (2003), Maddala and Wu (1999), Hadri (2000), Choi (2001), Shin and Snell (2002) and Levin (2002), whilst Banerjee (1999) and Baltagi and Kao

(2000) are considered to be early reviewers. There exists a substantial amount of literature on testing for a unit root in economic and financial variables to panel data sets (Cerrato, 2009; Pesaran et al., 2013). Cerrato (2009) argues that this research has been mainly driven by increased empirical applications including purchasing power parity and growth.

Pioneered by Levin et al. (2002) and Im et al. (2003), the commonly designated first-generation panel unit root test mainly focuses on panel data sets with uncorrelated cross-sectional errors, assuming that individual time series were independently distributed in the panel (Barbieri, 2006; Pesaran, 2007). This assumption is restrictive, especially in the context of regional regressions, and attempts to rectify this problem through cross sectional de-meaning of the series before applying the panel unit root test were unfruitful in cases where there were substantial differences across individual series in the pairwise cross-section covariances of the errors.

The second generation emerged to allow for errors that are cross-sectionally correlated in a number of applications, such as cross-country convergence and purchasing power parity (Pesaran, 2007). Maddala and Wu (1999) are the pioneers of the first of two approaches in this category. Smith et al. (2004), Chang (2004), Cerrato and Sarantis (2007) as well as Palm et al. (2011) then developed it further. This approach approximates the test of statistic distribution under CD in the panel by blocking resampling in order to preserve this pattern of such dependence. Although it follows structures of CD, the approach is more appropriate for a panel with large N and small N (Pesaran, 2013).

Bai and Ng (2004, 2010) popularise the second approach, which is based on the dual decomposing of the observed time series into idiosyncratic errors and common factors then applying unit root tests to both of the components. If the unobserved common factors are cointegrated it is also useful, hence it is called the panel analysis of nonstationary in idiosyncratic and common components.

The third approach was proposed by Pesaran (2007) and it augments the individual Dickey-Fuller (DF) regressions with cross-section averages of lagged dependent to account for error CD and first-differences of the individual series to deal with possible residual serial correlation (Pesaran, 2007; Cerrato, 2009; Pesaran et al, 2013). Based on Monte Carlo experiments, Pesaran' s test is shown to be desirable in a small sample in which there exists a single unobserved common factor, as it displays size distortions in the case where the number of common factors exceeds unity (Pesaran, 2007; Pesaran et al, 2013).

In most empirical applications, heterogeneous CD tends to be crucial. This paper employs the second-generation tests, the cross-section Dickey-Fuller (CADF) and the Im et al. (2003) CIPS tests based on Pesaran's (2007) approach in panel unit root framework to ensure that heterogenous CD is accounted for in a simple and intuitive way (Pesaran, 2007). In the CIPS test, the null hypothesis to be tested is that the series is homogenous when non-stationary against the alternative and that it is heterogeneous when stationary. The null hypothesis of the CADF test states that the series is non-stationary against the alternative that only a fraction of the series is stationary. Westerlund et al. (2016) put forward that the CADF and the Im et al. (2003) CIPS tests as used by Pesaran (2007) are the two most popular panel unit root tests, arguing that they have become the mainstays of the trade as they have wide applications.

The null hypothesis for the CIPS test is (homogenous – non-stationary). $H_0: b_i = 0$ for all i against the possibly heterogeneous alternative $H_0: b_i < 0$, i = 1, 2,……, N1; $b_i < 0$, i = N1 + 1, N1 + 2,……N in the CADF regression represented as follows:

$$DY_{it} = a_i + b_i * Y_{i,t-1} + c_i * mean\_Y_{i,t-1} + d_i * DY_t + \varepsilon_{it} \quad (4)$$

The implementation of this test is, however, subject to the presence CD, hence it is imperative to test for such effect. Aside from heterogeneity, CD and stationarity, the growth analysis in a dynamic panel framework raises the issue of endogeneity given the inclusion of lag-dependent variable as a regressor.

3.5 Endogeneity and Syst-GMM

This study considers the Syst-GMM approach to be an instrumental variable-based estimator. This estimator controls for district-specific effects, which is not possible using district-specific dummies due to the dynamic structure of the regression equation. This estimator has been chosen to control for simultaneity bias as some explanatory variables may be endogenous. In growth regressions, for instance, an issue that arises is the dual causality between investment, savings and economic growth (Attanasio et al., 2000) as each of these variables can be both endogenous and exogenous. The independent variables are likely to be endogenous and measured with error whilst some important variable such as the initial technology level and region- (district-) specific effects are not observable and are omitted in the estimation.

In a highly comparable and relevant study, Mairesse et al.,(1999) highlight that value added and age structure are determined simultaneously, such that establishments that are successful, for instance, recruit more workers, and the job candidates are usually younger than those that have left the organisation (Heywood et al., 2009). Differences between establishments are likely to drive results, and only part of the heterogeneity can be observed (Prskawertz, 2006). According to Addison et al. (2010), establishments with better industrial relations may retain their workers longer and still enjoy high levels of productivity. This assumption applies to the case under study, where there are several numbers of regions that have different age structures and economic performance. Therefore, the inability to control for district-level characteristics means that OLS estimates of equation (4) or within group estimations are likely to be biased. Indeed, this procedure is likely to yield biased estimates due to endogeneity resulting from bi-directional causality (Roodman, 2006; Alaali et al., 2015). Given the model in equation (2), there is a clear simultaneity challenge due to the fact the lagged dependent variable $Y_{i.t-1}$ is correlated with the time-invariant component. In order to control for endogeneity, an instrumental variable (IV)-type estimator, namely a Syst-GMM estimation (Arellano and Bover, 1995; Blundell and Bond, 1998; Bond, 2001; Roodman, 2006) is applied. The GMM growth estimate follows directly from Bond et al. (2001).

The impact of ageing on growth in equation (3) can, therefore, be expressed as follows:

$$Gva_{it} - Gva_{i,t-1} = (\alpha_o - 1)Gva_{i,t-1} + \beta_1 Age_{it} + \beta_2 Gcf_{it} + \beta_3 Emp_{it} + \mu_i + \varepsilon_{it} \qquad (5)$$

where Gva_{it} = natural logarithm of gross value added for district I at time t; $Gva_{i,t-1}$ = lag natural logarithm of gross value added; Age = natural logarithm logs of old-age dependency; Gcf = natural logarithm of gross capital formation; Emp = natural logarithm of gross employment rate variables; μ_i = the unobserved individual (district) effects, and $(\alpha_o - 1)$ = the speed of convergence in economic growth rates is measured the coefficient on the lag of natural log of gross value added.

The estimation of the parameters in a dynamic panel data model with unobserved individual specific heterogeneity is done by transforming the model into first-differences. Arellano and Bond (1991) proposed equation (8) to eliminate country-specific effects such that:

$$Gva_{it} - Gva_{i,t-1} = \alpha(Gva_{it-1} - Gva_{i,t-2}) + \beta_1(Age_{it} - Age_{it-1}) + \beta_2(Gcf_{it} - Gcf_{it-1}) + \beta_3(Emp_{it} - Emp_{it-1}) + (\varepsilon_{it} - \varepsilon_{it-1}) \qquad (6)$$

In an attempt to address the simultaneity bias of the independent variables and the correlation between $(Gva_{it-1} - Gva_{i,t-2})$ and $(\varepsilon_{it} - \varepsilon_{it-1})$, Arellano and Bond (1991) have suggest the use of sequential moment conditions, where lagged levels of the variables are used as instruments for the endogenous differences to estimate the parameters by GMM, called first-differenced GMM. The first-differenced GMM helps alleviate challenges related to endogeneity, measurement error and omitted variable bias issues, all of which are valid concerns in economic growth literature. Validity of this technique relies on the assumption that errors are not serially correlated and the lag of the explanatory variables is weakly exogenous. Since the lag of the dependent variable (GDP) is also on the right hand side of the equation, using lagged instruments ensures that the instruments are uncorrelated with the error term.

Following Arellano and Bond (1991), these following moment conditions are set:

$E|Gva_{it-s}.(\varepsilon_{it} - \varepsilon_{it-1})| = 0$ for s ≥ 2; t=3, ….,T (7)

$E|Age_{it-1}.(\varepsilon_{it} - \varepsilon_{it-1})| = 0$ for s ≥ 2; t=3, ….,T (8)

$E|Gcf_{it-1}.(\varepsilon_{it} - \varepsilon_{it-1})| = 0$ for s ≥ 2; t=3, ….,T (9)

$E|Emp_{it-1}.(\varepsilon_{it} - \varepsilon_{it-1})| = 0$ for s ≥ 2; t=3, ….,T (10)

The difference estimator above can control for region-specific effects and simultaneity, but has some shortcomings. Blundel and Bond (1998), Alonso-Borrego and Arrellano (1999) document the limitations of the first-difference model as follows: The first-differenced estimator is found to exhibit poor finite sample properties and if the lagged levels of the series are only weakly correlated with the subsequent first -differenced, then the instruments presented for the first-differenced equation are also weak. In addition, the first-differenced GMM performs poorly when the time observation is small and when the time series displays a persistent behaviour, that is, is non-stationary, which is highly likely in growth regressions as output is a highly persistent series. This issue leaves first-difference estimators susceptible to downward bias (see Blundel and Bond, 1998).

Arellano and Bover (1995) thus suggested an alternative system estimator that involves combining equation (9) and level equation (8). Blundel and Bond (1998) have reveal that this estimator has the ability to reduce biases and imprecision associated with first-difference estimator. The Syst-GMM is an extension of the first-difference GMM and includes a one-period lag difference of the explanatory variables as an additional instrument, with the key assumption that all variables are stationary. Arellano and Bover (1995) propose additional moment conditions for the second part of the system, that is, the regression in levels:

$E|(Gva_{it-s} - Gva_{i,t-s-1}).(\mu_i + \varepsilon_{it})| = 0$ for s = 1 (11)

$E|(Age_{it-s} - Age_{i,t-s-1}).(\mu_i + \varepsilon_{it})| = 0$ for s = 1 (12)

$E|(Gcf_{it-s} - Gcf_{i,t-s-1}).(\mu_i + \varepsilon_{it})| = 0$ for s = 1 (13)

$E|(Emp_{it-s} - Emp_{i,t-s-1}).(\mu_i + \varepsilon_{it})| = 0$ for s = 1 (14)

The Syst-GMM deals with endogeneity by solving the level and difference equations simultaneously, utilising instruments in the first-differences for the level equation in addition to using instruments in levels for the first-difference equation. The lagged values of the explanatory variables are used as instruments for contemporary values. In Syst-GMM, the instruments used in the first-differenced estimator include information about the endogenous variables, whilst the lagged differences contain information about the endogenous variables in levels. First-differences eliminate region-specific fixed effects and solve potential omission problems of the initial level of technology and other time invariant region-specific factors that influence economic growth. So doing ensures that this paper concentrates on the impact of the independent variables on gross value added and not vice versa. The result is that along with ensuring heterogeneity control, variations in district characteristics will be captured.

The Arrellano-Bond estimation is designed for small T and large N (Arrellano and Bond, 1991; Roodman, 2006), hence it is an appropriate technique to use in this study since there are 52 panels and 18 time periods. Two specification tests demonstrate the consistency of the GMM estimator. The first in the standard Hansen (1982) J-test of over-identifying restrictions with the null hypothesis validating the model. The J statistic is distributed as a χ^2 with degrees of freedom equal to the degree of over-identification as the empirical moments have zero expectation and the null is joint validity of all instruments. The second resulted from Arrellano and Bond's (1991) assertion that the instruments are only authentic if the residuals do not exhibit a serial correlation of order 2, AR(2). To this end, the Arrellano and Bond (1991) tested for autocorrelation in the idiosyncratic error term represted by ε_{it}. If the null in both tests is not rejected, support is provided for the estimated model.

Typically, GMM estimated are applied in one- and two-step variants (Arrellano and Bond, 1991). The one-step estimators utilise weighting matrices that are divorced from estimated parameters. The two-step GMM estimator employs optimal weighting matrices where the moment conditions are weighted by a consistent estimate of their covariance matrix. The two-step estimator is therefore asymptotically more efficient that the one-step estimator. Consequently, this study uses the moment conditions presented in equations (7) to (14) and adopts the two-step estimator.

3.6. Dynamic fixed effect
Considering a simple model,

$$Y_{it} = \phi Y_{i,t-1} + \beta_x X_{it} + \varepsilon_{it} \quad , |\phi| < 1 \tag{15}$$

for ι = 1,…………………,N, cross-sectional units and t = 1…………………,T, time periods, where, Y_{it} is the dependent variable, X_{it} is the k-dimensional vector of explanatory variables that are time varying, and $\varepsilon_{it} = \mu_i + \eta_{it}$ with μ_i indicates the individual specific fixed time-invariant effects.

There is a clear simultaneity problem since the lagged dependent variable $Y_{i,t-1}$ is correlated with the error term ε_{it} due to its correlation with the time-invariant component of the error term μ_i. Weinhold (1999) and Nickel (1981) argue that using fixed effects or least squares dummy variable in the presence of $Y_{i,t-1}$ does not eliminate at autocorrelation and this results in a bias, as discussed in Hsiao (2003). Assuming that omitted regressors are constant over time, the fixed effect solves the heterogeneity bias. However, if the omitted variables are not constant, the bias will persist. Moreover, it does not handle the endogeneity bias that will exist if the dependent variable and the age dependency are jointly determined such that shocks that affect output and gross capital formation jointly translate into changes in the employment structure (Gutierrez et al., 2017).

In dealing with this problem, the usual approach is to first-difference the data to remove the μ_i such that:

$$Y_{it} - Y_{i,t-1} = \phi(Y_{it} - Y_{i,t-1}) + \beta_x(X_{it} - X_{it-1}) + (\varepsilon_{it} - \varepsilon_{it-1}) \tag{16}$$

Due to the fact that ΔY_{it} is correlated with the first-difference error term, it becomes necessary to instrument for it. Anderson and Hsiao (1981) suggest the use of ΔY_{it-2} or Y_{it-2}, since these terms are not correlated with $\Delta\varepsilon_{it} = \eta_{it} - \eta_{it-1}$. From a practical point of view, good instruments for first-differenced dependent variable are difficult to find, thereby creating estimation problems (Weinhold, 1999). Furthermore, introducing dynamics into the panel model potentially induces bias by way of the heterogeneity of the cross-section units. Pesaran and Smith (1995) show that even with large N and T, estimates derived from pooled data are not consistent in dynamic models. This finding led to the consideration of a model in which the coefficient on the lagged dependent variable that is constrained to be equal across all cross-sectional units, so that equation (16) can be written in first-difference as follows:

$$Gva_{it} = \phi Gva_{i,t-1} + \beta_1 Age_{it} + \beta_2 Gcf_{it} + \beta_3 Emp_{it} + \mu_i + \varepsilon_{it} \tag{17}$$

Where, ι = 1 …N, t = 1…………………T refer to district and time dimensions, respectively.

If the coefficients on the lagged dependent variable are not constant across the cross section, significant bias is introduced, since the difference between the actual value and the estimated coefficients multiplied by the dependent variable will be a component of the error. Serial correlation induces the bias and there will estimation inconsistency (Weinhold, 1999). This bias is distinct from the fixed effects as shown by Pesaran and Smith (1995), thus instrumental variables will not address this bias. Hence, in this study, the dynamic fixed effects serves as a reference point to the main model, the Syst-GMM.

3.7 Conclusion

This chapter highlighted the basic principles of panel data analysis and, in the process, justified why this type of analysis is suitable for this study. It specified a model that is built upon the neoclassical framework and includes investment proxied by the gross capital formation and the labour proxied by the employment rate as the control variables. The main independent variable is the old-age dependency ratio, and its impact on the revenue or economic growth (proxied by gross value added) is the major concern of this study. Acknowledging the importance and implications of CD, the principle thereof was discussed prior to the CD test. The study suspects the existence of CD and therefore evaluated unit root tests, thereafter proposing the use of the CADF and CIPs unit tests, which were deemed superior. The section then explored the GMM approach and its ability to deal with endogeneity issues, and thus proposed the Syst-GMM estimation technique. The DFE model was also discussed as a superior method in the presence of CD.

CHAPTER 4: EMPIRICAL RESULTS

4.1 Introduction

This section provides the empirical findings. First, the results from the CD test are presented to validate the choice of the unit root tests and the estimation technique. Then, stationarity test results are provided, followed by the regression estimates. Lastly, Syst-GMM results are compared to those of DFE.

4.2 Data

The data was collected from Quantec Easy data. It is a balanced panel of annual observations from 52 districts over the period 1995 to 2013. In the estimations, the data was transformed into first-differenced natural logarithms of the variables owing to the presence of unit roots. To analyse the impact of an ageing population on economic growth in districts where the population is young and those where the population is old, we divided the data into young districts and old districts, based on the national value of the old-age dependency ratio, which is 7.85 as of 2016. Districts with an old-age dependency ratio of 7.85 and below are considered young districts, and those with a ratio above 7.85 are considered old districts.

4.3 Cross-sectional dependence test (CD)

It is important to check for the presence of CD for two reasons. It affects the choice of both unit root test and parameter estimation, and inference is heavily influenced by the interdependence of units across regions.

Table 3: Young and old district CD results

	All districts	Young districts	Old districts
Variable	CD test	CD test	CD test
lgva	130.50***	63.49***	65.89***
lage	154.37***	75.46***	26.56***
lgcf	75.46***	79.35***	73.49***
lemp	94.64***	41.85***	32.89***

Note: ***, **, * denote statistical significance at 1%, 5% and 10% level of significance respectively.

Table 3 provides the CD test results in the combined young and old districts. As conjectured, there exists interdependence across districts in terms of gross value added, ageing, investment and employment as shown by the significance of the CD test. This finding cements the choice of the stationarity test methods CIPS and CADF, which are designed to handle CD amongst regions. The results are not surprising given the economic structure of the South African economy, as it is an integrated economy that allows labour migration from one area to another. People move from rural areas to seek better opportunities in more developed districts such as Johannesburg, and entities relocate from one location to another whilst retaining multiple establishments across the country. Likewise, old people are likely to move to less developed districts where there is less noise and a friendly environment for retirement. Hence, the mobility of products services and the elderly also explains cross-sectional interdependence at the district level.

4.4 Stationarity test results

Table 4: CIPS and PESCADF

	Level		First difference	
	CIPS Z [t-bar]	PESCADF Z [t-bar]	CIPS Z [t-bar]	PESCADF Z [t-bar]
Variables				
lgva	-1.011	-4.426***	-3.920***	-7.244***
lage	-0.455	-3.368***	-1.453	2.640***
lgcf	-1.384	-5.488***	-3.424***	-6.631 ***
lemp	-1.349	2.838	-3.005***	-5.857 ***

Note: ***, **, * denote statistical significance at 1%, 5% and 10% level of significance respectively.

As seen in the table above, none of the variables under study is stationary in logged levels according to the CIPS test, whilst the PESCADF test indicates that only the employment variable is not stationary in logged levels. In attempting to derive stationary series, the variables are first-differenced. The CIPS test indicates that only the age variables remain non-stationary after first-differencing. The CADF test, on another hand, shows that at first-difference, all the variables become stationary. As a result, logged first-differences of the variable under study are used in to estimate the coefficients.

4.5 Syst-GMM estimates

Tables 5 and 6 present results for equations (6) and (4) for all young and all old districts respectively to show the impact of old-age dependency, gross capital formation and employment on output. The appropriateness of the Syst-GMM is based on the validity of the instruments used, in levels and first-differences. Panel B of both tables shows the results of the over-identification test and serial correlation test. Syst-GMM estimation of data that combines all districts yields serially correlated errors given that the p-value is lower 5%, which invalidates the instruments. In the young and old district categories, both p-values are greater than 5%, thereby confirming the validity of the instruments.

Table 5: Syst-GMM estimates (all, young and old districts)

Panel A: Regression estimates

Category	**All**	**Young**	**Old**
D.lAGE	-0.201***	-0.214***	-0.138***
	(0.014)	(0.044)	(0.044)
D.lGCF	0.172***	0.162***	0.185***
	(0.001)	(0.009)	(0.004)
D.lEMP	0.051***	0.082***	0.007
	(0.005)	(0.027)	(0.008)
_cons	0.020***	0.019***	0.019***
	(0.000)	(0.001)	(0.000)
D.lGVA L1.	0.062***	0.089***	0.073***
	(0.002)	(0.014)	(0.006)
Obs	884	459	425
Prob > F	0.000	0.000	0.000
Panel B: Diagnostic test			
Over-identification (Sargan test)	51.98	26.88	24.98
Sargan test, p-value	1.000	1.000	1.000
AR(2)	-2.69	-1.78	-1.93
AR(2), p-value	0.007	0.075	0.054

Note:***, **, * denote statistical significance at 1%, 5% and 10% level of significance respectively. J-test for over-identification test (Hansen, 1982) follows a χ^2 distribution with a null hypothesis of valid instruments. AR (2) is the second order correlation test in residuals proposed by Arrellano and Bond (1991). Standard errors are reported in parentheses.

According to Table 5, Syst-GMM evidence shows that, except for the employment variables in old districts, all the variables are significant at 5% level and possess the expected signs in the different categories. As expected, investment and employment have an enhancing effect on the gross value added. In line with expectations and the predictions of the lifecycle hypothesis, ageing exerts a negative effect on the output growth across districts. Considering all districts, a 1 percent increase in growth rate of ageing results in a 0.2 percent decline in growth rate of output as measured by the gross value added. The growth of gross capital formation and employment by 1 percent improves the output growth by 0.172 and 0.051 percent, respectively.

According to the results, in young districts, a 1 percent increase in ageing growth leads to a 0.214 percent decrease in growth of gross value added. A 0.162 percent growth in gross value added is realised following a 1 percent growth in gross capital formation, whilst a 1 percent growth in employment yields a 0.082 percent growth increase in gross added value.

In old districts, an increase in ageing by 1 percent leads to a 0.138 percent decrease in the growth of gross value added. Surprisingly, the impact of ageing on gross value added is greater in young districts than old districts. However, a 1 percent growth in gross capital formation is met by a 0.185 percent growth in gross added value. Hence, increasing investments generate better benefits in old districts than in young districts. These findings are counterintuitive as an investment is expected to have a greater effect in the young district while ageing is assumed to have more impact in old districts. This finding might be due to the inability of Syst-GMM to account for CD..

4.6. Dynamic fixed effects results

Sarafidis and Robertson (2009) show that under CD, IV and GMM estimators in the context of linear dynamic panel data models, standard moment conditions employed by these estimators are invalid, regardless of the lag length. Hence, in the presence of CD, the study considers the DFE, which controls for interdependence across panels.

Table 6: Dynamic fixed effects (All, young and old districts)

Category	**All**	**Young**	**Old**
D.lAGE	-0.195**	-0.062	-0.305***
	(0.083)	(0.124)	(0.099)
D.lGCF	0.197***	0.188***	0.213***
	(0.020)	(0.026)	(0.028)
D.lEMP	0.002	0.031	-0.039
	(0.041)	(0.058)	(0.055)
_cons	0.483***	0.830***	0.256
	(0.149)	(0.164)	(0.190)
EC	-0.059***	-0.062***	-0.049*
	(0.0123)	(0.013)	(0.026)

Note: ***, **, * denote statistical significance at 1%, 5% and 10% level of significance respectively. Standard errors are reported in parentheses.

With reference to Table 6, all the significant variables conform to the expected signs. The dynamic fixed effects estimates show that overall old-age dependency is negatively related to output, similar to the Syst-GMM estimates above, but is insignificant in young districts. Estimates from all the districts combined indicate that a 1 percent surge in the growth rate of ageing is associated with a 0.195 and 0.305 decrease in gross added value growth in all and old districts respectively. In line with expectations, this effect is stronger in old districts, with a 1 percent increase in ageing leading to a 0.305 percent decline in output growth. These results address the contrasting figures obtained from the Syst-GMM, in which the former is lower than the latter.

Similar to Syst-GMM estimations, DFE estimation results suggest a positive (as per expectation) impact of gross capital formation on the gross value added in all categories. DFE estimates in all districts combined indicate that a 1 percent increase in investment growth as measured by the gross capital formation will be associated with a 0.197 increase the growth of gross value added. In young districts, a 0.188 growth in gross value added results from 1 percent growth in gross capital formation whereas in old districts a higher 0.213 percent growth is realised following the same trigger in the gross capital formation. It can be argued that this phenomenon is likely, because in the old districts there is a greater percentage of the aged, hence labour performance is more compromised and investments will bring in better returns that in young districts, where there is a smaller proportion of the aged individuals..

The results from the DFE are more consistent across the different district categories in terms of the employment effect on gross added value. The employment variable is also not significant in all categories but conforms to expectations of a positive impact on the gross value added in all districts and in the young districts where higher employment leads to higher output. In the old districts, the impact is in fact negative. Ageing impact on savings and investment, has a decline in innovation and this has a negative implications on the growth of GDP hence a negative effect on revenue It can be argued that in old districts the greater proportion of the aged means that if they are employed, they will actually negatively affect gross added value.

In summary, the Syst-GMM and DFE results are generally similar in terms of the negative impact of ageing on gross value added, but the DFE reports greater impact in all districts. Further comparison suggests that, according to Syst-GMM, this negative impact is greater in young districts than in the old district, which is irregular. The DFE results oppose this finding, but are regular. Both methods offer similar results with regards to gross capital formation being positively related to gross added value in all categories. Although the impact is greater using DFE, the relative impact is the same for both methods, in that investments generate greater benefits where there is a greater proportion of the aged, i.e. in the old districts. Syst-GMM results insignificant impact of employment on gross added value in the old districts and minute impacts in all and young districts. DFE are more consistent, showing an outright insignificance in all categories.

Regarding the impact of ageing on growth, the results diverge from the findings by Fougere and Merette (1999) who used a dynamic CGE overlapping generations' model to examine the impact of population ageing on economic growth in seven OECD countries. Their findings indicates that, in the long run, population ageing actually creates more opportunities for investment in future human capital. Doing so would, in turn, raise labour supply, stimulate economic growth and significantly reduce the negative impact of ageing on per capita output. Our findings are also dissimilar to those of Fougere et al. (2009) who, through incorporating an endogenous labour supply in Canada, come to similar conclusions, arguing that increased participation of older workers may indicate the beginning of a new trends that will be amplified in the future. Faruqee and Muhleisen (2003) in their Japanese investigation of the phenomenon also draw the same conclusion.

Furthermore, Peng and Mai's (2008) dynamic CGE model of the Chinese economy show that increased movement of non-agricultural labour mitigates the erosion of standards of living resulting from declining labour supply generated by low fertility levels and population ageing. Increases in labour movement across sectors promote total output growth and real consumption. Likewise, Prettner's (2013) study concludes that in an endogenous model framework, population ageing has a positive influence on long-run economic growth. Prettner also argues that the population ageing effect depends on whether the long-run economic growth is decreasing or increasing.

The study findings are, however, comparable to the findings of other studies. In Göbel and Zwick's (2012) analysis of differences in age-productivity profiles between the service and manufacturing industries in Germany using GMM methodology, they conclude that ageing negatively impacts economic growth at varying degrees across sectors. This finding is in support of this current study's findings that ageing affects young and old districts differently. Parallels can also be drawn with Mahlberg et al. (2013), who also used the GMM method and fixed effects in Austria. Their results indicate that a negative and significant relationship exists between ageing and output in manufacturing and service sectors.

Hondroyiannis and Papapetrou's (2001) investigation on the relationship between low fertility rate, old-age dependency ratio and labour effort on economic growth in Greece using VECM also derives the same conclusion. Their results show that in the long run, declining fertility rates and increases in the old age-dependency ratio will lead to an overall decrease in the economic performance of the economy. Similarly, in Bloom et al.'s (2010) study on the relationship between population ageing and economic growth in Asia using a convergence model framework through OLS and two-stage least square regressions, their results show that higher old-age dependency ratios negatively affect growth only in the short run and not in the long run.

Tamirisa and Faruqee (2006) and Lindh and Malmberg (2009) used the OLG model to investigate population ageing in the Czech Republic and Scotland respectively. Both studies results indicate that population ageing will slow the growth of the economy and standard of living improvements as productivity declines. Similar are Peng's (2008) findings from People's Republic of China. Using the PRCGEM, Peng's findings are consistent with the neoclassical growth theory, in that population ageing leads to a declining growth rate of the labour force. The shrinking of the participation rates lowers the potential for growth in the economy, as demand for investment declines.

4.7 Conclusion

In sum, the Pesaran (2004) CD test results attest to the presence of CD, thereby affirming the choice of stationarity test methods. This study employed contemporaneous stationarity tests in the presence of CD, namely the cross-section CADF and the Im et al. (2003) CIPS tests as used by Pesaran (2007). Results show that variables are stationary after first-differencing, adopted in the DFE and Syst-GMM estimations. Ageing negatively impacts gross value added in combined, young and old districts – a finding in support of the lifecycle hypothesis. The impact is greater in the young districts. The results contradict a few studies that utilised OLG methodologies, but are similar to other studies that employed GMM and VECM techniques. Gross capital formation positively impacts the gross value added in the combined, old and young districts. Employment effect is mixed. Whilst Syst-GMM confirms a positive impact in combined and young districts, the variable is found to be positive but insignificant in old districts. The DFE estimates show that this variable is insignificant in the old and young districts.

CHAPTER 5: CONCLUSION

5.1 Study rationale

A number of nations across the globe are experiencing significant demographic changes. Population ageing has become one of the most prominent topics in economics research due to the possible implications of this phenomenon on economies. Statistics show that the population age structure in South Africa is gravitating towards an aged population, raising concerns about the impact on savings, investment and overall economic performance. As such, this study investigated the relationship between population age structure and economic performance at the district level using annual data from 1995 to 2013 on 52 districts in South Africa.

It employed dynamic panel methodologies, namely Syst-GMM and DFE. The study was framed within the neoclassical model in which output as measured by gross value added is dependent on old age-dependency ratio in addition to the traditional growth determinants such as investment and employment. Unlike the Syst-GMM, the DFE model has the ability not only to control for heterogeneity and endogeneity but also to control for CD, which is not controlled for by the Syst-GMM. Consequently, the study relied on the DFE estimates in investigating the impact of ageing on revenue, as proxied by the gross added value.

Overall, the results show that age dependency ratio is negatively related to gross added value, in line with lifecycle hypothesis. Ageing therefore negatively affects revenue at a district level in South Africa. Furthermore, when comparing the young and old districts, we found out that the impact of ageing is higher in old districts than in young districts, which also validates the lifecycle hypothesis. This finding can be attributed to differences in proportions of the aged, in that the more old-age individuals there are in a district, the greater the negative impact on the gross added value.

Investment as measured by gross capital formation is positively related to the growth of gross added value, also in line with expectations. Needless to say, the impact is also greater in old districts where capital investments are more likely to yield higher returns given that higher percentage of the old age individuals implies a smaller pool of capable workforce. Capital investments therefore are a prudent option under these circumstances, generating greater benefits in districts with more aged individuals than those other districts. The employment variable is insignificant in explaining output, which was expected since the aged population will not contribute significantly to the production process given that generally they are not part of the employment bracket. If they are employed, it is likely that they will negatively impact on the gross added value, perhaps by compromising the product quality.

5.2 Recommendations

These results suggest that, from a policy point of view, South Africa must be concerned about the growth in population ageing. A policy designed to improve the economic performance should monitor population ageing in an attempt to avoid the resultant growth slowdown given the results presented above. Efforts must be made to promote the adoption of new and innovative techniques to mitigate the effects of population ageing, which include dampened growth, savings and investments.

There are some opportunities for further research. The study has looked at savings through the channel of investment. Although investing population ageing and growth through savings may not be supported by empirical setup of this study, it is the author's belief that investigating the link between these two factors might shed further light on the nexus between an population ageing and economic growth.

APPENDIX 1(<u>Definitions of words on the Study)</u>

Words	Definitions
Fertility rate	It is the ratio of live births in a geographical area to the population of that area. This ratio is expressed per 1000 population per year birth rate.
Mortality rate	This is the average annual number of deaths during a particular year per 1,000 in a population.
Gross Value Added	Provides a rand value for the amount of goods and services produced, minus the cost of all inputs and raw materials that are in the production process
Old Age dependency ratio	Measures the number of elderly people of 65 years above as a share of working age which are those individual between 15 to 64 years.
Gross Capital Formation	Is an increase in net investment (which is the total value of gross fixed capital formation changes in inventories minus disposals). It is the constant in this study.
Employment	It consists of all persons of working age who during a particular period, such as one week or one day, were either in paid work or self-employment.
EC (Estimated Error Correction Form)	It can be used to estimate the average delay in the transmission of shocks.

APPENDIX 2 (List of old districts)

List of Old Distrists

P1D04: Overberg (DC3)	Western Cape	Bredasdorp
P1D05: Eden (DC4)	Western Cape	George
P1D06: Central Karoo (DC5)	Western Cape	Beaufort West
P2D01: Cacadu (DC10)	Eastern Cape	P.E
P2D02: Amathole (DC12)	Eastern Cape	East London
P2D03: Chris Hani (DC13)	Eastern Cape	Queenstown
P2D04: Joe Gqabi (DC14)	Eastern Cape	Barkly East
P2D05: O.R.Tambo (DC15)	Eastern Cape	Mthatha
P2D06: Alfred Nzo (DC44)	Eastern Cape	Mount Ayliff
P2D07: Nelson Mandela Bay (NMA)	Eastern Cape	P.E
P2D08: Buffalo City (BUF)	Eastern Cape	East London
P3D02: Namakwa (DC6)	Northern Cape	Springbok
P3D03: Pixley ka Seme (DC7)	Northern Cape	Der Aar
P4D01: Xhariep (DC16)	Free State	Trompsburg
P4D05: Fezile Dabi (DC20)	Free State	Sasolburg
P5D01: Ugu (DC21)	KZN	Port Shepstone
P5D04: Umzinyathi (DC24)	KZN	Dundee
P5D10: Sisonke (DC43)	KZN	Ixopo
P6D02: Ngaka Modiri Molema (DC38)	North West	Mahikeng
P6D03: Dr Ruth Segomotsi Mompati (DC39)	North West	Vryburg
P9D01: Mopani (DC33)	Limpopo	Giyani
P9D02: Vhembe (DC34)	Limpopo	Thohoyandou
P9D03: Capricorn (DC35)	Limpopo	Polokwane
P9D04: Waterberg (DC36)	Limpopo	Modimolle
P9D05: Greater Sekhukhune (DC47)	Limpopo	Groblersdal

List of Old Districts			
Provinces	Districts	Proportion	Number
Western Cape	P1D04: Overberg (DC3)		
6	P1D05: Eden (DC4)	50%	3
	P1D06: Central Karoo (DC5)		
Eastern Cape	P2D01: Cacadu (DC10)	100%	8
8	P2D02: Amathole (DC12)		
	P2D03: Chris Hani (DC13)		
	P2D04: Joe Gqabi (DC14)		
	P2D05: O.R.Tambo (DC15)		
	P2D06: Alfred Nzo (DC44)		
	P2D07: Nelson Mandela Bay (NMA)		
	P2D08: Buffalo City (BUF)		
Northern Cape	P3D02: Namakwa (DC6)	40%	2
5	P3D03: Pixley ka Seme (DC7)		
Free State	P4D01: Xhariep (DC16)	40%	2
5	P4D05: Fezile Dabi (DC20)		
KZN	P5D01: Ugu (DC21)	27%	3
11	P5D04: Umzinyathi (DC24)		
	P5D10: Sisonke (DC43)		
North West	P6D02: Ngaka Modiri Molema (DC38)	50%	2
4	P6D03: Dr Ruth Segomotsi Mompati (DC39)		
Limpopo	P9D01: Mopani (DC33)	100%	5
5	P9D02: Vhembe (DC34)		
	P9D03: Capricorn (DC35)		
	P9D04: Waterberg (DC36)		
	P9D05: Greater Sekhukhune (DC47)		

APPENDIX 3

List of New Districts				
Provinces	Districts	Proportion	Number	
Western (	P1D04: Overberg (DC3)			
6	P1D05: Eden (DC4)	0.5	3	
	P1D06: Central Karoo (DC5)			
Eastern Ca	P2D01: Cacadu (DC10)	1	8	
8	P2D02: Amathole (DC12)			
	P2D03: Chris Hani (DC13)			
	P2D04: Joe Gqabi (DC14)			
	P2D05: O.R.Tambo (DC15)			
	P2D06: Alfred Nzo (DC44)			
	P2D07: Nelson Mandela Bay (NMA)			
	P2D08: Buffalo City (BUF)			
Northern (	P3D02: Namakwa (DC6)	0.4	2	
5	P3D03: Pixley ka Seme (DC7)			
Free State	P4D01: Xhariep (DC16)	0.4	2	
5	P4D05: Fezile Dabi (DC20)			
KZN	P5D01: Ugu (DC21)	0.27	3	
11	P5D04: Umzinyathi (DC24)			
	P5D10: Sisonke (DC43)			
North We	P6D02: Ngaka Modiri Molema (DC38)	0.5	2	
4	P6D03: Dr Ruth Segomotsi Mompati (DC39)			
Limpopo	P9D01: Mopani (DC33)	1	5	
5	P9D02: Vhembe (DC34)			
	P9D03: Capricorn (DC35)			
	P9D04: Waterberg (DC36)			
	P9D05: Greater Sekhukhune (DC47)			

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