

# ECONOMIC IMPLICATIONS OF AGEING LITHUANIAN POPULATION

**Gindra Kasnauskienė\***

*Vilnius University*

**Marija Andriuškaite**

*Vilnius University*

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**Abstract.** *Increased life expectancy combined with declining birth rates and massive emigration flows have caused many to worry about the various impacts of an ageing population in Lithuania. This suggests a very big increase in the dependency ratio and is consequently a cause for concern about a future slowing of economic growth. However, there is little research carried out regarding economic or financial effects of this phenomenon in the country. The aim of this paper is to evaluate the impact of Lithuanian ageing population on economic variables. A new research design is implemented by using VAR and ARMAX models to compare two different approaches, treating ageing as an endogenous and exogenous variable. The authors find that old age dependency ratio has no statistically significant impact on Lithuania's GDP growth, employment rate, final household consumption and gross national savings in the short run. The results achieved can be explained by incomplete and only short run data available for Lithuania. Also, joining the EU and other favorable economic conditions might have boosted Lithuania's economic performance over the whole research period and significantly reduced the negative effects of ageing population. However, the impact of shifts in the structure of population age might soon come into effect, as Lithuania's society is gathering the pace of ageing, which is also seen in other emerging markets that are progressing toward becoming advanced.*

**Key words:** *population ageing, economic growth, labour force, consumption, savings*

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## 1. Introduction

Many countries are experiencing a rapid ageing of their populations. It is increasingly becoming one of the main topics on the agendas of many international organizations, governments and scientific institutions. The shifts in the population age structure are inevitable, that is why it is very important to thoroughly analyze the possible impacts of ageing on economies and businesses. It might seem that the ageing population is a challenge faced by developed countries as a result of improving health care and living condi-

\* Corresponding author: Vilnius University, Faculty of Economics, Sauletekio av. build. II, room 819, Vilnius, LT-03103, Lithuania, phone: +370 5 236 6143, email: gindra.kasnauskienė@ef.vu.lt

tions. The issue is quite widely researched in USA (Ahmedova, 2011; Maestas, 2016), European Union (Doran, 2012; Kasnauskienė & Michnevič, 2015) and especially in Japan, where the ageing population is a very relevant topic (Oliver, 2015). However, there is an increasing number of studies regarding the ageing population, demographic shifts and their implications on economies of emerging countries as well, as these markets tend to “catch” global ageing trends quite fast (The World Bank, 2013; Jorgensen, 2011; Hanlin, 2014).

In the context of ageing population, Lithuania is not an exception. Total fertility rate has declined since the end of the 1960s to the level of 1.7 in 2015, which is below the 2.1 children required to maintain a stable population. In addition, improvements in living standards and health care have led to an increase in life expectancy. As a result, the share of the elderly is increasingly growing, while the proportion of young people in the country is decreasing, also due to the high emigration rates of working age population.

In fact, the ageing of Lithuanian population and its impact are mostly investigated from a social angle. The Lithuanian authors are analysing a general society’s attitude, the social and labour policy towards elderly people (Burbulienė, 2006), the relationship between the young and the old generations, the social and economic problems that might rise because of age difference (Gedvilaitė-Kordušienė, 2013), the trends of population ageing and the challenges of social security system (Kanopienė & Mikulionienė, 2006) as well as the factors which cause the ageing of population (Garlauskaitė & Zabarauskaitė, 2015). However, there is a lack of research from economic perspective, which is aimed to investigate how ageing affects economics quantitatively.

The challenges of ageing population have been addressed by Lithuania’s government as well. The National Strategy of Overcoming the Consequences of Population Ageing, based on the Madrid International Plan of Action on Ageing and the Political Declaration (2002), was commenced in 2003. As the Madrid plan states, the National strategy is aimed mainly to improve social life, health care and general life quality of the elderly (Nacionalinė gyventojų senėjimo pasekmių įveikimo strategija, 2003). The five priority areas set for certain measures to be implemented are: guarantee of stable income, employment and activity, social health care, beneficial living conditions and social activities for elderly people. Although these measures needed sufficient amount of finance to be implemented, the strategy did not evaluate any economic or financial effects or consequences of ageing and focused mostly on social aspects of an ageing population. A new action plan of overcoming the consequences of Lithuania’s population ageing in 2017–2019 is set to be announced by the Ministry of Social Security and labour of Lithuania in 2017, which means that at the moment there are no publically available further government plans on acting in this emerging issue.

It should be noted that population ageing is already becoming a governmental and international concern. Some international organizations as well as national ones are evaluating the ageing effects on Lithuania’s economy. International credit rating agency Moody’s has stated in the country report that the accelerating population ageing is de-

creasing the labour force, the country's competitiveness and even the general potential of economic growth, which in the future might negatively affect the financial stability of the country. Moody's analysts forecast that by 2060, the ageing population might result in additional government expenses that might comprise up to 2% of GDP (Moody's, 2016). Similar projection is highlighted by the National audit office of Lithuania. Their report on fiscal stability of Lithuania points out that the accelerating ageing of population creates an evident risk for fiscal stability of the country (Valstybės kontrolė, 2016). The analysts project that by 2036, the ageing related government expenses will rise by as much as 2% of GDP and by 2036, the public debt might rise up to 54.2% of GDP because of ageing population (Valstybės kontrolė, 2016).

As there is little research investigating the economic outcomes of demographic shifts in the country, this research aims to evaluate the impact of Lithuanian ageing population on the main economic variables: GDP growth, employment rate, final household consumption and gross national savings. The originality of the paper comes from the comparison of two different approaches: the authors evaluate the impact of ageing on economic variables in both endogenous and exogenous terms.

The paper is organized as follows: the following part reviews the literature on relationship between population ageing and various social, economic and financial variables. Further, the methods used to investigate whether the selected variables are truly interrelated and have any impact are described. In the next part the results of the analysis are presented, including comments on the economic interpretation. In section five we discuss some limitations of the study and suggestions for future research. In conclusions section the results are summarized.

## **2. Literature review**

Population ageing is becoming a more and more widely discussed subject in both scientific institutions and international organizations; there are many studies exploring the relationship between ageing and various social, economic, and financial variables (Samuelson, 1958; Modigliani, 1966; Oliver, 2015; Maestas et al., 2016; Jorgensen, 2011; Nagarajan et al., 2013; etc.). Three main areas can be distinguished where scientists are mainly focusing on the model and evaluate the impact of ageing – that is, economical growth, labour market, and trends of consumption and saving. The interaction among population ageing and these three areas will be discussed further.

### ***2.1 The impact of ageing on labour market.***

Demographic age structure shifts can affect labour productivity and labour market mainly in three ways: 1) ageing decreases innovation and entrepreneurship; 2) ageing increases expenditure on health, pensions and public investments, which are necessary to improve labour productivity, and decreases tax revenue; 3) ageing decreases the consumption of human capital and economy of scale (The World Bank, 2013). These state-

ments can be justified by researches carried out in this field. By using VAR model and deriving impulse – response functions and analyzing Granger causality, Doran (2012) found that old-age dependency ratio has a negative impact on labour productivity and real GDP of Ireland. Similar negative impact was recorded by Didžgalvytė & Lukšaitė (2014). By using regression models, the authors found that an increase in the share of population over 65 years decreases the employment and economically active population. By using the same variable as an ageing proxy – the share of population aged over 65 years, Maestas et al. (2016) has found that because of ageing, the labour productivity per capita decreases, thus slowing down economic growth and GDP per capita growth. Furthermore, a few surveys have been carried out in Europe (Henkens et al., 2008; Wieteke et al., 2012) to investigate how employers deal with the ageing of labour force. Both surveys' results showed that employers are aware of the fact that labour force faces challenges related to population ageing – decreasing productivity, increasing production costs, and the decreasing size of the labour force. Four main ways how employers are dealing with the decreasing labour demand were indicated: 1) employing people from so called minority groups: immigrants, disabled people, pensioners; 2) recruiting retired employees; 3) short-run employment when it is needed; 4) using technical capital more than human capital (Henkens et al., 2008). However, both surveys have showed that in spite of the fact that employers are expecting decrease in labour productivity and labour force in general, only a small part are willing to employ more retired people. A negative impact on the size of labour force, labour productivity and employment because of ageing labour force was also found by Winkelmann-Gledd (2011), Bloom et al. (2015), Lisenkova et al. (2012). Based on these findings, it is expected that ageing population has a negative impact on Lithuania's labour market.

## ***2.2 The impact of ageing on economic growth***

Bloom et al. (2001) notices that ageing could have a negative, a positive or no impact at all on economic growth. Nevertheless, economic growth is a very aggregated variable, so it is natural that population ageing, which affects many social, cultural, economic areas, will also have impact on the whole economy performance. Elgin & Tumen (2010) found that economic growth and population ageing can be balanced if human capital demanding technologies are replaced with technical capital demanding technologies, that is, if firms are reorganizing the production technology from people to equipment. A few other researches also found that ageing can have a positive impact on GDP growth (Prettner, 2011; Oliver, 2015). Opposite results were recorded in a research by Hondroyannis & Papapetrou (2001). Their vector autoregressive error correction model (VECM) showed that the increase in old age dependency ratio has a negative impact on labour productivity and GDP growth in the long run. Hondroyannis & Papapetrou (2001), Bloom et al. (2010) and Feldstein (2006) point out another important issue – a so called “double ageing” – a phenomenon, related with increasing

life expectancy and decreasing fertility rates, resulting in a faster increase of aged population share. Because of this effect, the authors expect a negative impact on economic growth. Kasnauskienė & Michnevič (2015), by constructing a panel regression model and analyzing EU countries, found that an increase in younger age group has a positive effect on real GDP growth, and an increase in older age group has a negative impact on real GDP growth. So, despite a few findings of positive relationship between population ageing and economic growth, it is expected that this demographic shift will have a negative impact on Lithuanian economic growth.

### *2.3 The impact of ageing on consumption and saving*

In 1958, an influential American economist Paul Samuelson introduced an Overlapping Generations Model (OLG) which helps to understand transfers between generations (from worker to retiree) (Samuelson, 1958). His theory sees an individual's life cycle as consisting of two periods: one as a productive worker phase and another one as an unproductive retiree period. Samuelson assumes that "workers could not carry goods over into their retirement years" (Samuelson, 1958, p. 481), the products of a worker's labor have to be consumed immediately, thereby making a worker incapable of saving for his/her own retirement. In other words, the retirees rely upon those who are still in the workforce for their sustenance. An Overlapping Generations Model is commonly used while researching economic growth in the frame of interactions among economic agents from different generations, especially when modeling pension savings and public finance (Arthur & McNicoll, 1978; Galor, 1992; Aglietta et al., 2007; Cipriani, 2014; Muto et al., 2012; Ahmedova, 2007; Lisenkova et al., 2012).

The theory of "life cycle" derived by F. Modigliani (1966) argues that younger people tend to save more, while older people tend to consume more. In the light of ageing population, this could indicate that increasing share of older population will have a positive impact on consumption, while decreasing share of younger population will have a negative impact on saving. This assumption is supported by Haiming & Xiuli (2015); Hanlin (2014); Ahmedova (2007); Borsch-Supan & Winter (2001); Jorgen (2011). Wong and Tang (2013) takes the ageing, consumption and saving interaction even further. They find that younger people tend to save more, because they expect to finance their needs when retired. Keeping in mind the increasing life expectancy, not only young people increase their saving, but older people tend to save more as well. Hagemann & Nicoletti (1989), Albuquerque & Lopes (2010) claim that the ageing of population will affect not only the volume of spending and consumption, but the structure of consumption as well. Age is one of the most important factors in consumers' preferences. The increasing share of aged people will increase the demand of goods and services intended for older people, such as medical assistance, dietary supplements etc., and decrease the share of demand for goods and services intended for younger people, such as education, transport, even housing. So businesses will have to adjust their sup-

ply for different age groups. A different approach is taken by the World Health Organisation (2015) which claims that because of the “life cycle” theory, old age dependency ratio should be interpreted with caution. As older people often have savings, they are usually able to not only finance their needs, but support their children or grandchildren as well. Also, statistics show that more cash flow is generated from older people to younger people in the family and not vice versa, so it is not always correct to call older people dependent. This could be escalated even further by taking into account that older people are not only able to consume more themselves, but are also indirectly financing the consumption of younger people. To conclude, it is expected that population ageing will increase the volume of consumption in Lithuania and decrease the volume of saving.

### 3. Methodology

Based on literature review above, research hypotheses were stated and appropriate research methods were selected. As it was mentioned before, the aim of this research is to quantitatively evaluate how Lithuanian ageing population impacts the main economic variables: GDP growth, employment rate, final household consumption and gross national savings. The main research hypotheses to be tested in this study are:

- H1: population ageing has a negative impact on Lithuania’s economic growth, employment rate and gross national savings.
- H2: population ageing has a positive impact on Lithuania’s final household consumption.

The literature review suggests the most commonly used methods for investigating the interaction between population ageing, economic growth, labour market, saving and consumption. These are OLG models, regression analysis, VAR/VECM models, statistical analysis and surveys (Hondroyannis & Papapetrou, 2001; Burbulienė, 2006; Doran, 2012; Nagarajan et al., 2013; Garlauskaitė & Zabarauskaitė, 2015, Lisenkova et al., 2012; Borsch-Supan & Winter, 2001; Ahmedova, 2007). OLG models, while very commonly used in researching ageing population effects on macroeconomics, mostly focus on public finance, pension reforms, savings or general economic development. However, the purpose of this research is to capture the causal relationships among these factors, that is why VAR model is selected as the most appropriate method. Based on literature review, it can be assumed that population ageing, economic growth, labour market trends, consumption and saving might be interrelated and might form a joint system, and VAR models can capture multidimensional autoregressive time series (Enders, 2010; Virbukaitė, 2011). However, because of specification principles, the parameter coefficients of VAR have no economic, or in other way interpretable meaning. To capture short-run effects in coefficients, a structural form VAR (SVAR) should be estimated (J. Gottschalk, 2001). However, a significant number of parameter restrictions should be applied and there is not enough empirical research done to have

substantive justification to restrict the parameters of population ageing and economic variables, so the model would be too unstable and sensitive to unsound assumptions. Therefore the authors chose to use unrestricted, standard form VAR. Also, VAR model will be used only as a means to apply Granger causality tests, impulse-response functions and forecast error variance decomposition.

The research design of the model can be described as follows:

- Appropriate variables are selected to describe population ageing, economic growth, labour market, consumption and saving to be fitted into VAR model. VAR model is estimated.
- Granger causality test is applied to investigate causal relationships among variables.
- Impulse – response functions are derived to investigate the effects of one variable's impulse on remaining variables in the VAR system.
- Decomposition of forecast error variance is derived to investigate how dependable the variables are on each other's changes.

The method designed above enables us to investigate whether the selected variables are interrelated. Impulse – response functions and the decomposition of forecast error variance will enable us to quantitatively measure the impact of ageing on economics. In this way the authors believe that the selected methodology will make it possible to fulfill research goals, that is, to evaluate how population ageing affects economics of Lithuania.

As most researches regarding population and its effects on economics are implemented in developed countries, most common assumptions and methods might give contradicting results, as will be explained in the following parts of the paper. The authors believe that because of scientific experiment, it would be worth testing a different approach in emerging market like Lithuania and comparing it with common assumptions. In this way, the authors implement a new approach regarding ageing, which was not encountered while reviewing the literature before. The commonly used research methods mentioned above often regard ageing as an endogenous variable, closely interrelated with economic variables. However, ageing as a more social than economic phenomenon can have an exogenous impact on economics. To investigate exogenous effects of the variables, ARMAX models – autoregressive time series models with exogenous variables are commonly used (Andrews et al., 2013). The authors believe that it is worth testing whether ageing affects economic growth, labour market, consumption and saving externally, so four ARMAX models are constructed. These two different approaches – considering that ageing might impact economics both endogenously and exogenously will allow us to compare and evaluate the implications of demographic shifts on economic variables.

As it was mentioned above, appropriate variables were selected to build a VAR model. Quarterly Lithuania's GDP official statistics data were selected to describe economic growth over the period 2004–2015. The variable to describe labour market is

employment rate in quarterly terms, covering the same time period. Final household consumption was selected to describe consumption trends in Lithuania on quarterly terms for 2004–2015. Gross national savings are selected to describe saving trends in Lithuania on quarterly terms for 2004–2015. Although household savings were used more often in previous researches, unfortunately, this variable was not available for Lithuania. On the other hand, gross national savings also include household savings. To describe ageing, old age dependency ratio was selected as the most commonly used variable for population ageing in previous researches. Old age dependency ratio is the ratio of people aged over 65 years and people aged from 15 to 65. Unfortunately, only annual time series were available for Lithuania, so quarterly time series had to be linearly interpolated.

These variables were renamed for more convenient modeling as follows: Lithuania's GDP – BVP, old age dependency ratio – SEN, employment rate – U, final household consumption – NUV, gross national savings – NS. The time series consist of 48 observations.

#### 4. Main results of empirical research

To guarantee the stability of VAR model, all variables must be stationary (Lutkepohl, 2005). Based on variable's graphs, two stationarity tests are used – the most common Augmented Dickey Fuller (ADF) test (Said & Fuller, 1984) and Andrew-Zivots test, as graphs indicate a structural break in time series around 2009 (Zivot & Andrews, 1992; Maddala & Kim, 2003). Both tests' results are presented in Table 1 and 2 accordingly.

TABLE 1. Unit Root ADF test results

Variable	Lags	Critical statistics value	Test statistics value	Decision
Log(BVP)	1	-2.93	-2.06	$H_0$ not rejected
U	4	-2.93	-1.18	$H_0$ not rejected
Log(NUV)	2	-2.93	-1.69	$H_0$ not rejected
Log(NS)	3	-2.93	-1.66	$H_0$ not rejected

Source: calculated by the authors

TABLE 2. Unit root Andrews - Zivot test results

Variable	Lags	Critical statistics value	Test statistics value	Decision
Log(BVP)	1	-4.80	-3.26	$H_0$ not rejected
U	7	-5.08	-4.56	$H_0$ not rejected
Log(NUV)	2	-4.80	-4.00	$H_0$ not rejected
Log(NS)	0	-4.80	-4.68	$H_0$ not rejected

Source: calculated by the authors

The null hypothesis, saying that the variables are unstationary cannot be rejected with significance level 0.05, as in all cases critical statistics value is lower than test statis-



tics value. Andrews- Zivot Unit Root test also indicated the structural break date – that is 20<sup>th</sup> observation, corresponding with the break in the first quarter of 2009, which was seen in the graphs of time series.

After the variables had been differentiated one time, both ADF and Andrews-Zivot tests were repeated. Their results are presented in Table 3 and 4 accordingly.

TABLE 3. Unit Root ADF test results for differentiated variables

Variable	Lags	Critical statistics value	Test statistics value	Decision
Diff(Log(BVP))	0	-1.95	-3.28	H <sub>0</sub> rejected
Diff(U)	3	-1.95	-2.03	H <sub>0</sub> rejected
Diff(Log(NUV))	1	-1.95	-2.33	H <sub>0</sub> rejected
Diff(Log(NS))	2	-1.95	-6.67	H <sub>0</sub> rejected

Source: calculated by the authors

TABLE 4. Unit root Andrews - Zivot test results for differentiated variables

Variable	Lags	Critical statistics value	Test statistics value	Decision
Dif(Log(BVP))	0	-4.80	-4.90	H <sub>0</sub> rejected
Dif(U)	0	-5.08	-6.60	H <sub>0</sub> rejected
Dif(Log(NUV))	5	-4.80	-4.97	H <sub>0</sub> rejected
Dif(Log(NS))	2	-4.80	-8.57	H <sub>0</sub> rejected

Source: calculated by the authors

The null hypothesis saying that the variables are unstationary was rejected with significance level of 0.05, as in all cases critical statistics value was higher than test statistics value. So, all variables are differentiated at the first level to become stationary.

Before a VAR model is constructed, cointegration tests should be applied to test whether variables are cointegrated, that is, whether they are related on long-term equilibrium. If they are cointegrated, the VAR model should be expanded with error correction component – a VECM model should be constructed (Sargan, 1964). Most commonly used cointegration tests are Engle-Granger two-step procedure and the Johansen procedure. As there are more than two variables in the model, the Johansen test is more appropriate. Furthermore, this test allows identifying the exact number of cointegrating vectors (Sorensen, 2005). There are two tests applied in the Johansen procedure – trace statistics and maximum eigenvalue. The Johansen procedure results are presented in Table 5.

The null hypothesis saying that there are no cointegrating vectors, R=0, can be rejected with significance level 0.05 in both tests, because test statistics are higher than critical values. The second null hypothesis, saying that there are not more than one and the third null hypothesis saying that there are not more than two cointegrating vectors can also be rejected because test statistics are higher than critical values with significance level 0.05. The fourth null hypothesis saying that there are not more than

TABLE 5. Cointegration test results

Johansen procedure tests	$H_0: R=0$		$H_0: R\leq 1$		$H_0: R\leq 2$		$H_0: R\leq 3$		$H_0: R\leq 4$	
	Test statistics value	Critical statistics value	Test statistics value	Critical statistics value	Test statistics value	Critical statistics value	Test statistics value	Critical statistics value	Test statistics value	Critical statistics value
Trace statistics	163.62	76.07	84.38	53.12	43.84	34.91	<b>19.44</b>	<b>19.96</b>	4.43	9.24
Eigenvalue statistics	79.24	34.40	40.54	28.14	24.40	22.00	<b>15.01</b>	<b>15.67</b>	4.43	9.24

Source: calculated by the authors

three cointegrating vectors cannot be rejected with significance level 0.05 because test statistics are lower than critical values. So, it can be concluded that the variables are cointegrated and that there are three cointegrating vectors. It means that the VAR model should be supplemented with an error correction component to become a VECM model. However, this need should be justified with the statistical significance of disequilibrium adjustment coefficients in VECM (Enders, 2010).

TABLE 6. Disequilibrium adjustment coefficients in VECM equations

Equation	Log(BVP)		SEN		U		Log(NUV)		Log(NS)	
ECT <sub>1</sub> value	1.13034	0.35	1.483546	0.42	49.5666	0.22	2.6344567	0.01*	17.656682	0.03*
p value										
ECT <sub>2</sub> value	-0.3849	0.12	-0.94766	0.02*	-3.1148	0.69	0.0842946	0.64	-0.476998	0.75
p value										
ECT <sub>3</sub> value	-0.0118	0.28	-0.03698	0.03*	-0.0720	0.84	0.0089432	0.28	0.011141	0.87
p value										

Source: calculated by the authors

P values in all error correction coefficients show that only a few of them are significant – p value is less than significance level 0.05. (Table 6). Only the second and the third error correction coefficient in the old age dependency ratio equation are significant and only the first error correction coefficients are significant in final household consumption and gross national savings equations. This means that remaining variables do not react to the long-run disequilibrium. Despite the fact that cointegration tests showed the variables to be cointegrated, there are not enough statistically significant error correction components to build a VECM model. Thus, a VAR model is constructed.

4 lags are included in the VAR model to remove unwanted autocorrelation in model residuals (Lutkepohl, 2011). The model can be described as:

$$X_t = a + A_1 X_{t-1} + A_2 X_{t-2} + A_3 X_{t-3} + A_4 X_{t-4} + e_t \quad (1)$$

$$\text{where } X_t = \begin{bmatrix} \text{Diff}(\log(\text{BVP})) \\ \text{Diff}(\text{SEN}) \\ \text{Diff}(U) \\ \text{Diff}(\log(\text{NUV})) \\ \text{Diff}(\log(\text{NS})) \end{bmatrix}, a - \text{constant, } e_t - \text{residuals component}$$

When the VAR model is built, Granger causality tests are applied (Table 7).

The null hypothesis says that the variable has no Granger effect on other variables. As can be seen from Table 8, the null hypothesis cannot be rejected with significance level 0.05 with old age dependency ratio, employment rate and final household consumption variables. It means that these variables have no Granger effect on other VAR variables. So, the test shows no direct impact of ageing on economics. On the other hand, Granger causality does not mean logical causality. It only means that the variable has little effect on other variables forecasts.

To see how economic growth, employment rate, final household consumption and gross national saving respond to the impact of old age dependency ratio, impulse-response functions are derived from the VAR model. These functions are accumulated for 20 periods ahead, that is, for 5 years ahead (See Figure 1).

TABLE 7. Results of Granger causality test

Variable	H <sub>0</sub> p value
Diff(Log(BVP))	p = 0.0004
Diff(SEN)	p = 0.4149
Diff(U)	p = 0.3482
Diff(Log(NUV))	p = 0.0998
Diff(Log(S))	p = 0.0003

Source: calculated by the authors

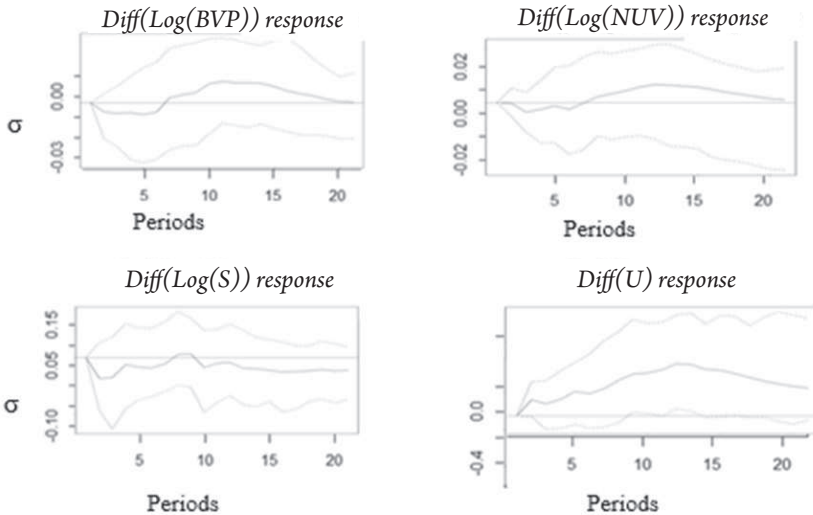


FIGURE 1. Impulse-response functions from the old age dependency ratio equation

Source: calculated by the authors

It can be seen that when the impulse in the VAR system comes from old age dependency ratio, the response of all other variables fades away in 5 years, so the effect is quite short. Furthermore, the responses are very slight, only a few decimals of standard deviation of the variable. Having in mind confidence intervals in dotted lines, it is possible that GDP growth, final household consumption, gross national savings and employment rate would not react to the impulse of old age dependency ratio – their responses would be negligible and close to zero. So, the hypotheses, which were assumed based on literature review, cannot be confirmed – the effect of ageing on economics could be negligible based on impulse-response functions analysis.

The decomposition of forecast error variance helps to show what part of the variable variance changes can be explained by the changes in other variables (Lutkepohl, 2007). As it is seen from the forecast error variance decomposition for 20 periods, the biggest part – 99% of the GDP and employment rate changes are caused by the variables themselves. The effect of other variables is negligible. Old age dependency ratio changes can be explained by the changes in the variable itself and partly the changes in gross national savings. Later it becomes more dependent on GDP. Final household consumption dispersion is best explained by old age dependency ratio's dispersion in the first period. Later the biggest effect comes from GDP changes. Gross national savings dispersion is best explained by final household consumption, later it is more dependent on GDP dispersion. To conclude the analysis of forecast error variance decomposition, it is seen that the variables dispersion is mostly explained by their own or GDP dispersion, which means they are highly autoregressive. It could be possible that they are not interrelated so that VAR would be the best model to investigate the relationship among the variables.

The results of the VAR model analysis answer the research questions:

- Although the cointegration tests showed even three cointegrating vectors existing among the variables, their response to the disequilibrium is insignificant. Granger causality test showed no Granger effect of old age dependency ratio on economic variables. Decomposition of forecast error variance showed that variables are mainly dependent on their own dynamics, implying that ageing and economic variables are not closely interrelated.
- Impulse – response function analysis showed almost negligible impact of ageing on GDP growth, employment rate, final household consumption and gross national savings.

Based on the findings, the authors suggest a new approach regarding the ageing variable. It would be appropriate to investigate the relations among aging, economic growth, employment rate, final household consumption and gross national saving while treating the old age dependency ratio as an exogenous variable. To test this assumption, ARMAX models are constructed for each of the dependent variables (Kongcharoen & Kruanpradit, 2013; Andres et al., 2013). The models are constructed in the following way:

1. The best autoregressive model is selected for each of the variables.
2. The dependent variable is filtered with the autoregressive filter of the independent variable to avoid spurious regressions.
3. Statistically significant correlations between the dependent variable and the independent variables model residuals are investigated to select the appropriate independent variables lag to include in the ARMAX model.
4. The statistically significant lags of the independent variable are included in the autoregressive dependent variables models as an exogenous variable (Enders, 2010).

Four ARMAX models were constructed, where dependent variables were Lithuania's GDP growth (dy), employment rate (du), final household consumption (dnuv) and gross national savings (dns), and the independent exogenous variable is old age dependency ratio (SEN). Based on autocorrelation and partial correlation functions, autoregressive models were constructed for each of the variable (standard error of the coefficients is shown in brackets):

$$SEN_t = 24.95 + 0.99*SEN_{t-1} + e_t \quad (2)$$

(2.4916) (0.0014)

$$dy_t = 0.02 + 0.53*dy_{t-1} + e_t \quad (3)$$

(0.0081) (0.1218)

$$dnuv_t = 0.02 + 0.35*dnuv_{t-2} + e_t + 0.43*e_{t-3} \quad (4)$$

(0.0072) (0.1369) (0.1334)

$$dns_t = 0.02 - 0.39*dns_{t-3} + e_t \quad (5)$$

(0.0161) (0.1305)

$$du_t = 0.09 + 0.37*du_{t-1} + e_t \quad (6)$$

(0.1363) (0.1348)

As it is seen, all of the coefficients in the autoregressive models are statistically significant and no further corrections are needed. The following procedure is to filter the dependent variables with the autoregressive filter of the independent variable. That is, every coefficient in the autoregressive equations will be multiplied by the autoregressive filter of the old age dependency ratio equation, which can be written as follows:

$$(1-a_1L)*SEN_t = b+e_t \quad (7)$$

where

- a – autoregressive coefficient,
- L – lag operator,
- b – intercept,
- e – error component.

After the filter is applied, the cross correlation functions should be analyzed between every dependent variable and the errors from the autoregressive model of ageing. This needs to be done to find out the statistically significant lags of ageing to be included in the ARMAX models (Enders, 2010). As it seen from the results of calculation, there are no statistically significant correlations between Lithuania's GDP growth, final household consumption, employment rate, gross national savings and the errors of the old age dependency ratio autoregressive models. It could mean that population ageing has no impact on economic variables as an exogenous variable. The four ARMAX models were constructed below (standard errors are shown in brackets):

$$dy_t = 0.17 + 0.49*dy_{t-1} - 0.006*SEN + e_t \quad (8)$$

(0.1212) (0.1241) (0.0049)

$$dnuv_t = -0.01 + 0.31*dnuv_{t-2} + 0.26*SEN + e_t + 0.34*e_{t-3} \quad (9)$$

(0.0291) (0.1451) (0.2532) (0.1702)

$$dns_t = 0.21 - 0.34*dns_{t-3} - 0.008*SEN + e_t \quad (10)$$

(0.0114) (0.1293) (0.0114)

$$du_t = -1.82 + 0.35*du_{t-1} + 0.076*SEN + e_t \quad (11)$$

(2.1847) (0.1361) (0.0874)

As it is seen, the coefficient of old age dependency ratio is statistically insignificant in all the ARMAX equations. Furthermore, the inclusion of an exogenous variable has lowered the significance of the remaining variables. When old age dependency ratio is implied as an exogenous variable, no statistically significant impact was found on economic variables.

## 5. Discussion and limitations

Although the literature review strongly implied the inevitable impact of population ageing on economics and strong interrelations among economic variables and the ageing, the analysis of Lithuania's case did not prove this assumption. When ageing was implied as an endogenous variable, the common research method in this area, a VAR model, did not show any Granger effects of ageing on economic variables. Moreover, impulse-response functions only showed a short-run and almost negligible response of economic variables to the impulse of the old age dependency ratio. The forecast error variance decomposition analysis showed that all the variables are highly autoregressive and mainly dependent on their own dynamics. These results suggested that ageing could have not endogenous, but exogenous impact on economics. However, the four ARMAX models did not show any statistically significant effects of ageing on Lithuania's GDP growth, employment rate, final household consumption and gross national savings. These results could have been caused by a few limitations.

Firstly, the origin of the data in the time series could have influenced the estimation of the VAR and ARMAX models. Previous researches were conducted in countries where annual data was available for at least a few decades. There was no such data availability in Lithuania's case. Sufficient data points for all the variables were only available on a quarterly basis starting with 2004. Although all the time series were seasonally adjusted, it could still influence the results. Also, ageing is a long-term phenomenon that can be investigated through a long time period, which is not possible in Lithuania at the moment.

Secondly, the ageing variable itself – the old age dependency ratio – is not flawless either. It was linearly interpolated from annual to quarterly data. The interpolated data, as well as the original, has a very noticeable deterministic trend, making the variable's dynamics very different from the remaining variables. To make sure the variable is stationary, it was differentiated, but because of the interpolation, the differences are the same each year. This means that the variable has little economic information. On the other hand, the original time series has a strong linear trend, too, and the yearly growth rate is slow and constant.

Thirdly, the insignificant effect of the ageing population on economics could have been caused not only by the previously mentioned flaws in the data, but the general economic situation in Lithuania, too. The country experiences economic growth, sustained by joining the European Union and the Euro zone, which maintains a positive effect on all economic indicators throughout the time series. So it is possible that ageing does not have a noticeable effect at the moment (SEB bank, 2016). However, this positive effect is expected to fade away and the trends and impact of fastening ageing of the population, which is seen in the developed countries, will be soon noticed in Lithuania as well. It is also not unusual that strong evidence of ageing having a negative impact on economics present in developed countries might be harder to be statistically captured in developing countries. A bibliometric analysis of articles regarding the subject done by Nagarajan et al. (2013) highlights that the influence of ageing on economics varies a lot among different countries, mainly caused not only by different methodological approaches, but also by different stages and processes of economic development. The study focused on articles acquired from Scopus database regarding the effect of ageing on economics through years 1975–2013 and found that 17% of empirical researches showed no influence of ageing, mostly in developing countries (Nagarajan et al., 2013). This can also be explained by lack of long-term data and different extent of population ageing processes in developed and emerging markets.

Overall, the research results in the case of Lithuania imply that it might be fairly complicated to quantitatively evaluate the ageing effects on economics in developing countries, because there might be both positive and negative factors influencing exceptional economic performance of emerging markets, while the elements of surprise are less likely in the economies of developed countries. These factors might influence the statistical and causal relationships among ageing and economic variables. Nagarajan et al. (2013) claim that “the absence of empirical studies on ageing and economic growth for less developed countries combined with the fact that the ratio of an older popu-

lation in such countries is expected to significantly increase over the next thirty years makes this topic an imperative for future research” (Nagarajan et al., 2013, p. 1). That is why it is essential to continue investigating the demographic shifts in emerging markets and look for new methodical approaches regarding this issue.

## 6. Conclusions

It is a well known fact that population ageing is already long underway and has been playing out with varying degrees of intensity across different countries. Lithuania is not an exception; all the ageing indicators show that the population is becoming older more rapidly than ever before. However, there is little empirical evidence about the magnitude of population ageing effects on the country’s economic indicators.

The results of previous research show that population ageing tends to have a negative impact on labour market indicators, economic growth and trends of saving, and could have a positive effect on consumption trends.

Although the authors implemented a new approach by evaluating both endogenous and exogenous effects of population ageing on economic indicators, these assumptions could not be proven for Lithuania’s case. The endogenous ageing effect in the VAR model with old age dependency ratio, GDP growth, final household consumption, gross national saving and employment rate as variables, did not show any Granger effect of ageing on economics. Furthermore, the impulse – response analysis identified only a short-run and almost negligible response from economic variables when the impulse comes from the ageing variable. The decomposition of forecast error variance showed that variables are mainly dependent on their own dynamics, meaning they are highly autoregressive. To sum up, while treating ageing as an endogenous variable, it did not show to have an impact on economics.

The VAR model results suggested building ARMAX models, where ageing is included as an exogenous variable. However, according to the results of our calculations, no statistically significant effect of ageing on economics was found, either. The new approach of treating ageing as internal and external factor did not confirm the strongly implied ageing effects on economics found in previous researches.

These results indicating that population ageing has no impact on economic variables may be explained by incomplete and only short-run data available for Lithuania. Also, Lithuania’s economic growth boost after joining the European Union might have significantly reduced the negative effects of ageing population. However, the impact may soon come into effect, as Lithuania’s society is ageing faster, and high emigration rate is even increasing the ageing ratios. The research results in the case of Lithuania imply that it might be complicated to evaluate the ageing effects on emerging markets because of various exceptional factors, which are not that common in economically advanced countries. This demonstrates a strong need for further research of economic impact of population age structure shifts and exploring new methodological approaches to investigate the issue.



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