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# HOW DEMOGRAPHY AFFECTS THE ECONOMY – IMPACT OF POPULATION AGEING ON INFLATION

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**Abstract:** The motivation of this paper is to check whether inflation is linked to the population age structure. To check this hypothesis, a panel data model is used. We regress the changes in CPI on a set of macroeconomic variables. The results of the estimations suggest that there may be a relation between demography and low-frequency inflation. A larger old-age dependency ratio is correlated with lower inflation. This may confirm some of the previous empirical findings that ageing is deflationary when related to increased life expectancy.

**Keywords:** population ageing, inflation, demography

**JEL classification:** C23, J10

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## INTRODUCTION

In the nearest future many advanced economies will face the demographic change. Not only are we experiencing a slowing population growth due to decreasing fertility rates. A deterioration in fertility rates among increased longevity leads also to population ageing. In almost all advenced economies the ratio of elderly people in the population increases. The pace of this increase is also getting quicker. According to OECD population projections, over the next 50 years

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ageing will be rapid, with old-age dependecy ratios more than doubling in many developed countries.

At the same time, many of these economies are facing a very low inflation level. Inflation that was high in most countries in the 1970s, is now chronically low. A conventional approach would suggest that population ageing as a slow-moving trend is not connected to inflation, which is a monetary phenomenon. However, recently in the public debate the opinion appeared that low inflation levels may be linked to changing demographic population structures (see eg. Shirakawa 2011a,b, 2012, 2013; Bullard et al. 2012). Therefore, a larger share of the elderly in advanced economies may make it more difficult to exit the low inflation trap. If there really exists a link between demography and inflation, it may also cause significant implications for the conduct of monetary policy.

Therefore a motivation of this paper is to check whether changes in the age structure of population can impact inflation, especially whether the rise of the old-age dependency ratio is correlated with lower inflation rates. In order to achieve this, firstly, the character and strength of this relation will be analysed. Secondly, it will be checked whether one can distinguish between the effects on inflation caused by two different dependent groups, namely changes in the shares of young (aged 0-15) and elderly (aged 65 and over) population. The main focus is however set on elderly population.

The reminder of this paper is organized as follows. In the Literature review the hitherto literature is being presented and discussed. The second section describes the data and the methodology used in the empirical analysis. It also presents key facts about population ageing in the analysed countries. Finally, the last section investigates empirically the link between inflation and demography in selected economies and concludes.

## LITERATURE REVIEW

To the best of the author's knowledge there is still little evidence on the hypothesis on impact of population ageing on inflation. Moreover, few empirical studies that have been devoted to this topic remain non-conclusive on the sign of the impact of demographic changes on inflation.

The existence of a link between inflation and age-structure of population was regularly mentioned by Shirakawa [2011a, 2011b, 2012, 2013]. The former Governor of the Bank of Japan has repetedly stated that an ageing population could lead to an increase in deflationary pressures, primarily due to expectations of a slowdown in economic growth. In addition, it may cause a reduction in the size of consumer demand and investment. Looking at the hitherto publications on inflation and demography, two contradictory streams of research can be distinguished.

The more popular and traditional view emerges from the life-cycle hypothesis. As the median age of population increases, more households finance their consumption from before accumulated savings and do not directly produce

added value. Therefore the discrepancy between aggregate demand and output in the economy rises and demand-driven inflationary pressure appears. Simultaneously, as the labour supply is shrinking, wages are being pushed up, which increases inflation through the cost channel.

In line with this theory, McMillan & Baesel [1990] confirm the forecasting power of demographics for low-frequency inflation. They use correlation between demographics and inflation in the United States to predict the moderation of inflation in the 1990s. Lindh and Malmberg [2000] describe the impact of demographics on the existence of low-frequency inflation using a panel model. They estimate the relation between inflation and age structure on annual OECD data 1960–1994 for 20 countries. According to their results increases in the population of net savers dampen inflation, whereas especially the younger retirees fan inflation as they start consuming out of accumulated pension claims.

More recently, Juselius and Takáts [2015], who performed a panel data analysis on 22 advanced economies over the 1955-2010 period, suggest that population ageing could lead to increased inflationary pressures. Their estimates show that demography accounts for 1/3 of the variation in inflation in the analysed period. They find a stable and significant relationship between the age structure of a population and low-frequency inflation. In their following work, Juselius and Takáts [2016] confirm that the age-structure of population is a systematic driver of inflation. According to their research, in the US this age-structure effect accounts for about 6.5 percentage points of disinflation between 1975 and 2016.

Recently new views appeared in the literature and another outlook on the link between low inflation and ageing gained on popularity. One of the arguments are the demand-side effects of population ageing. Changing consumption preferences would lead to reduced aggregated demand and lower inflation. Analyzing lifecycle consumption and saving patterns (see eg. Ando and Modigliani 1963) suggests that net consumers cohorts (dependents) drive up the real equilibrium interest rate. This trend was analyzed by Anderson et al. [2014], who by using the IMF GIMF Model finds deflationary pressures from ageing, stemming mainly from declining GDP growth and falling land prices.

Yoon et al. [2014] conduct a panel data analysis to prove that population ageing has economically and statistically significant impact on key macroeconomic variables. They find that while population growth is inflationary, in the long run dependant cohorts appear to have negative inflationary pressures.Their estimation proves that in the long run societies with larger dependant age groups and smaller working age population face a statistically significant decline in hours worked, real rates, savings and investment and higher inflation.

Konishi and Ueda [2013] argue that ageing could be more deflationary when caused by increased life expectancy. This is because the government is motivated to appease older voters by supporting the income of the elderly by increasing income tax rates. In general, rising ageing-related government spending can be financed either by income tax or by producing inflation. Rising income tax

increases the burden for younger generations who are economically active. Producing inflation is however costly mostly for bond-holders, who are in general the older generation. Therefore, when there are more elderly people in the society, their political influence rises. Also empirical research conducted for Germany by Faik [2012] and for a sample of OECD countries by Gajewski [2016] show that demographic ageing exerts downward pressure on prices.

Effects of ageing may also depend on its causes. According to Katagiri et al. [2014] ageing is deflationary when caused by an increase in longevity but it is inflationary when caused by a decline in birth rate. Using a OLG model, they proved that over the past 40 years ageing caused yearly deflation of about 0.6 percentage points in Japan. Also Konishi and Ueda [2013] show that the direction in which the ageing of the population affects the inflation rate depends on the roots of this process. They state that population ageing stemming from a decline in the birth rate generates inflation by shrinking the tax base and raising fiscal expenditure.

## DATA AND METHODOLOGY

In the study the largest possible available sample of OECD countries is included. The sample covers 32 economies: Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Latvia, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, and United States.

As to show the age structure of population we use three different variables. First, the dependency ratio (denoted as $dep_{i,j}$, where i=1,…,N is a country index and j=1,…,T is a time index) captures the share of the non-active age population, which is economically dependent. It is the number of the young (aged 0–14) and the old (aged 65 and more) population divided by the working age population (aged 15-64). Therefore

$$dep_{i,j} = (n_{i,j}^{young} + n_{i,j}^{old})/n_{i,j}^{working\ age}.$$

Another variable of interest is the youth dependency ratio that covers the number of the young population (aged 0-14) divided by the working age population (aged 15–64). It is denoted as

$$ydep_{i,j} = n_{i,j}^{young}/n_{i,j}^{working\ age}.$$

Third demographic variable is the old-age dependency ratio, which shows the proportion of elderly people to the working age population and is denoted as follows:

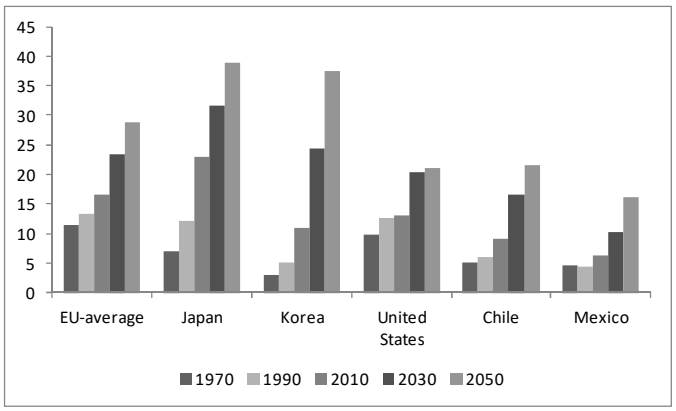
$$olddep_{i,j} = n_{i,j}^{old}/n_{i,j}^{working\ age}.$$

As mentioned in the Introduction, the developed world is currently experiencing a shift in the age composition of populations. Fertility rates are

decreasing and as the so-called baby-boomer generation marches through working age, the workforce is ageing. Furthermore, due to gains in longevity, the share of the elderly in population is rising.

These demographic changes have already begun in some of the analysed countries (such as Japan). In other – eg. Mexico - this change is occuring more slowly and population is still relatively young. Nevertheless, in the whole sample in the analyzed period the average share of people aged 65 and more in the society rose from 10% in 1971 to 16.8% in 2015. Forecasts predict that in the future this share will be growing further, reaching as much as 27% in the year 2050.

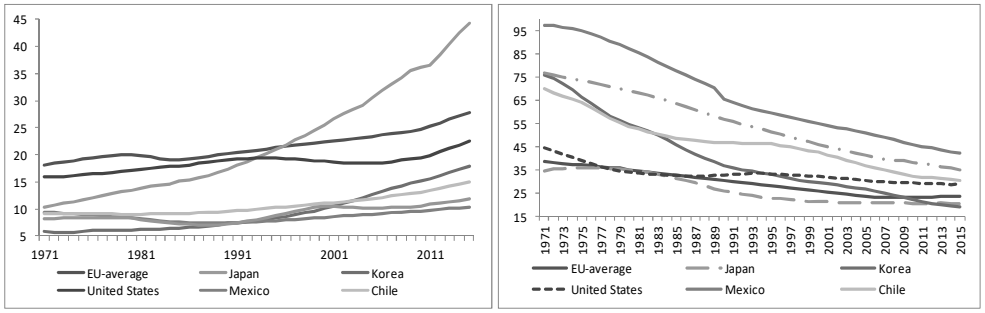
Figure 1. Elderly population (65 and more) as % of total population in selected OECD countries




Source: OECD database

Looking at the development of the old-age dependency ratio over the analyzed period, one can notice it has been growing steady in most countries in the sample, with the noticeable exception of Japan, where the pace of population ageing is faster than in other economies (see Figure 2, left panel). At the same time we are also experiencing a declining youth dependency ratio (see Figure 2, right panel). In the analyzed time period its mean value in the countries in the sample dropped from 45.5% to 25.6%. According to OECD forecasts, it will stabilize at 20–25% till 2050.

Figure 2. Old-age dependency ratio in selected OECD economies, 1971–2015 (left panel), Youth dependency ratio in selected OECD economies, 1971–2015 (right panel)



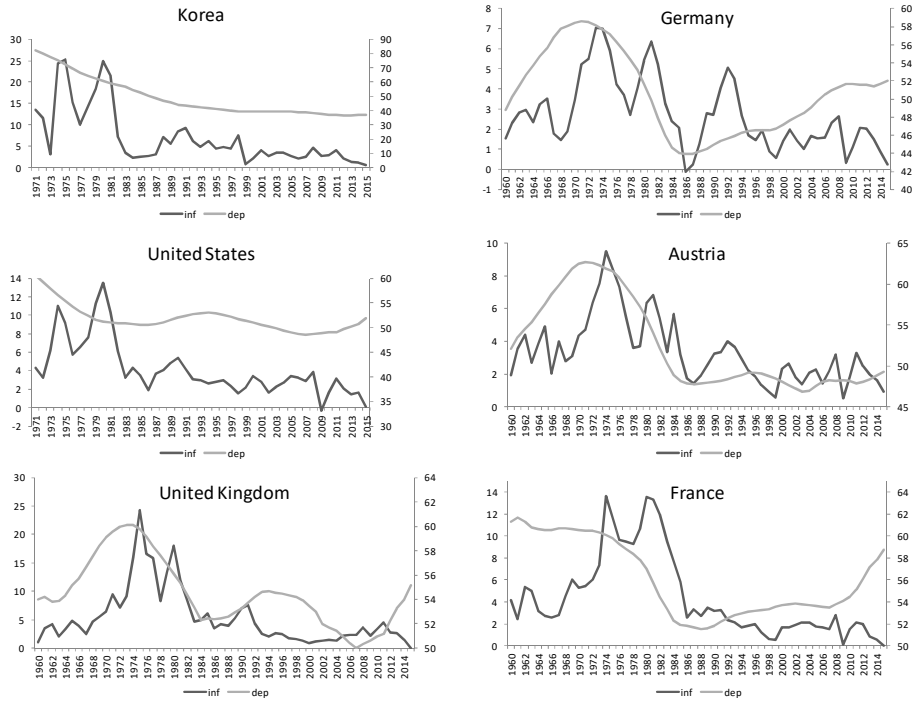

Source: OECD database

As mentioned in the Introduction, these demographic developments coexist with another economic trend, which has been lately observed in several ageing countries, namely historically low inflation. Since 1971 the average inflation rate in the analyzed countries dropped from 7.13% to 0.41%. In recent years in some of these countries inflation rates became even negative. Although for most of the analyzed period there is a visible heterogeneity between countries in the sample, in the 2000s years inflation rates have moderated and decreased in all countries.

In order to include inflation in the model we take the yearly inflation rate, obtained from OECD database. As low-frequency inflation dynamics are analyzed, yearly data are sufficient. The inflation rate is denoted as $inf_{i,j}$, where i=1,…,N is a country index and j=1,…,T is a time index. Following Gajewski [2016] the sample has been truncated from above at an inflation rate of 25% in order to exclude periods of sharp macroeconomic instability. Leaving those variables could create serious bias in estimation results.

Following Juselius and Takáts [2015] we begin with a simple graphical comparison of two variables – inflation and dependency ratio as a common measure of the demographic change. In order to maintain the clarity of the text, Figure 3 shows this comparison only in chosen six of the analysed economies. A first look at the data does reveal that there may be some relationship between inflation and demography. In the long run they seem to correlate.

Figure 3. Inflation rate (lhs, %) and dependency ratio (rhs, %) in selected economies




Source: OECD database

This relation may be however purely coincidental. Inflation may be driven by some common factors across countries (as before the late 1980s, it was strongly driven by such factors as oil price shocks). Also these variables, especially dependency ratio have been more or less similar across countries. Therefore, this relationship recquired a more careful analysis that considers other variables.

The general empirical model is given by equation (1). We index country by *i,* where i=1,2,3,…,N and year by *j,* where j=1,2,3,…,T.

$$inf_{i,j} = \alpha_0 + \alpha_1 \cdot dep_{i,j} + \alpha_2 \cdot tot_{i,j} + \alpha_3 \cdot m_{i,j} + \alpha_4 \cdot ggdp_{i,j} + \alpha_5 \cdot budbal_{i,j} + \varepsilon_{i,j} \quad (1)$$

We regress inflation on dependency ratio as the demographic variable, as well as other, control variables. They have been added in order to better capture relations between inflation and demography. The choice of control variables is based mainly on Yoon et al. [2014], who have analyzed how different demographic variables (such as population growth, shares of specific age groups or life expectancy) influence macroeconomic variables – economic growth, inflation, savings and investment and fiscal balances.

Among the control variables, there are:
$tot_{i,j}$ – which denotes the yearly change in the terms of trade index (Source: OECD database)
$ggdp_{i,j}$ – denotes the annual growth rate of real GDP (Source: OECD database)
$m_{i,j}$ – denotes the base money growth rate (Source: IFS)
$budbal_{i,j}$ – which denotes the annual change of general government deficit (Source: OECD database).

In the next step, in order to check the hypothesis whether the impact of different dependent age groups on inflation is different, variable *dep* is divided into two categories: young dependency ratio ($ydep_{i,j}$) and old-age dependency ratio ($olddep_{i,j}$). Therefore, equation (2) looks as follows:

$$inf_{i,j} = \alpha_0 + \alpha_1 \cdot ydep_{i,j} + \alpha_2 \cdot olddep_{i,j} + \alpha_3 \cdot tot_{i,j} + \alpha_4 \cdot m_{i,j} + \alpha_5 \cdot ggdp_{i,j} + \alpha_6 \cdot budbal_{i,j} + \varepsilon_{i,j} \quad (2)$$

Table 1. Descriptive statistics for the model variables

| Description | Obs. | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| CPI rate (annual, %) | 1301 | 7.25 | 7.11 | -4.48 | 25 |
| (population aged 0-14 and population aged 65 and more)/population aged 15-64 | 1440 | 52.68 | 8.40 | 36.79 | 107.05 |
| population aged 0-14/population aged 15-64 | 1440 | 33.39 | 11.61 | 19.54 | 97.60 |
| population aged 65 and more/population aged 15-64 | 1440 | 19.28 | 5.52 | 5.62 | 42.52 |
| base money growth rate (annual, %) | 1099 | 14.81 | 16.43 | -25.42 | 144.80 |
| growth rate of real GDP (annual, %) | 1274 | 2.90 | 3.26 | -14.72 | 26.28 |
| change in the terms of trade index (annual, %) | 1273 | 0.01 | 5.63 | -100 | 49.28 |
| change of general government deficit (annual, %) | 726 | -2.02 | 4.40 | -32.12 | 18.70 |

Source: own calculations

Table 1 presents descriptive statistics for the variables used in the model. Only for demographic variables there is no missing data in the analyzed period. The data for recent decades is the most complete in the sense of having less missing values. This results mainly from the changes in political and economic systems in many European countries.

## RESULTS AND CONCLUSIONS

The results of estimations are presented in Table 2. The regression equation parameters are initially estimated using OLS. In the first form of the model, with dependency ratio as the only demographic variable, a positive and significant impact on inflation has been observed. A growth in dependency ratio of 1 percent leads to 0.101 change in inflation. The relationship between inflation and demography cannot therefore be rejected. To further check this hypothesis, we perform the regression equation using fixed effects (FE) and random effects (RE). In the fixed effects model there also seems to be a positive relationship between inflation and dependency ratio. The coefficient by variable $dep_{i,j}$ is positive (0.297) and significant at the 1% level. We apply a modified Wald statistics for

groupwise heteroscedasticity in the residuals and the Woolridge test for serial correlation, following Gajewski [2016]. These tests show that both problems exist in the sample and should be controlled for as the FE estimator may be inefficient and lead to biased standard errors. As the Wooldrigde test is significant and rejects the null hypothesis, indicating the presence of serial correlation, the model is estimated using the GLS method, which analyses panel-data linear models by using feasible generalized least squares. This allows to estimate in the presence of AR(1) autocorrelation within panels and cross-sectional correlation and heteroskedasticity across panels. Again, the parameter by the variable $dep_{i,j}$ is positive, albeit this impact is expected to be smaller. A growth in dependency ratio of 1 percent led to a positive change in infation (0.065).

Table 2. Estimation results

| 1971-2015 | OLS | FE | RE | GLS | OLS | FE | RE | GLS |
|---|---|---|---|---|---|---|---|---|
| dep | 0,101* | 0,297*** | 0,160*** | 0,065* | | | | |
| | (-0,039) | -0,031 | -0,028 | -0,029 | | | | |
| ydep | | | | | 0,114** | 0,269*** | 0,137*** | 0,118*** |
| | | | | | -0,036 | -0,029 | -0,025 | -0,029 |
| olddep | | | | | -0,173*** | -0,285*** | -0,164*** | -0,249*** |
| | | | | | -0,032 | -0,068 | -0,038 | -0,033 |
| m | 0,222*** | 0,141*** | 0,193*** | 0,071*** | 0,172*** | 0,093*** | 0,161*** | 0,039** |
| | (-0,032) | -0,019 | -0,019 | -0,012 | -0,027 | -0,019 | -0,019 | -0,012 |
| ggdp | -0,1 | -0,256*** | -0,159** | -0,072** | -0,225*** | - 0,306*** | -0,227*** | -0,105*** |
| | (-0,069) | -0,051 | -0,051 | -0,028 | -0,065 | -0,047 | -0,049 | -0,026 |
| tot | -0,128** | -0,129*** | -0,127*** | -0,103*** | -0,119*** | -0,115*** | -0,121*** | -0,102*** |
| | (-0,041) | -0,031 | -0,033 | -0,016 | -0,034 | -0,029 | -0,031 | -0,014 |
| budbal | -0,102** | 0 | -0,099* | -0,077*** | -0,107*** | 0,04 | -0,106** | -0,069*** |
| | (-0,034) | -0,052 | -0,04 | -0,018 | -0,032 | -0,048 | -0,035 | -0,014 |
| obs. | 526 | 526 | 526 | 526 | 526 | 526 | 526 | 526 |
| F-test | 12,82 | 42,34 | | | 31,87 | 56,7 | | |
| | 0 | 0 | | | 0 | 0 | | |
| Wald chi² | | | 175,46 | 100,91 | | | 308,67 | 456,2 |
| | | | 0 | 0 | | | 0 | 0 |
| R² | 0,26 | | | | 0,39 | | | |
| R² within | | 0,3 | 0,27 | | | 0,41 | 0,36 | |
| R² overall | | 0,15 | 0,24 | | | 0,32 | 0,39 | |

Notes:
Significance at the 1%, 5% and 10% levels are denoted respectively by ***, **, *.
Std. errors in parentheses.
In GLS panel-specific autocorrelation AR(1) imposed.

Source: own calculations

The next step is to divide dependency ratio into its components (young dependency ratio and old-age dependency ratio) in order to check the hypothesis whether the impact on inflation of old dependents may differ from the impact of young dependents. Indeed, different results have been obtained. In each specification the negative and significant effect of increasing old-age dependency ratio has been confirmed. An increase of old-age dependency ratio of one percentage translates into a 0.29 to 0.16 percent decrease in the average inflation rate. This may confirm the hypothesis that ageing is deflationary. Also, regardless of the specification a significant and positive effect of an increase in young dependency ratio has been observed. The results are robust to different time periods, control variables and estimation techniques.

The results of this empirical analysis add to the ongoing discussion on the relationship between demography and inflation rate. They suggest that demographic changes may have deflationary impact in the next years, particularly in those economies, where significant population ageing is currently experienced or expected. There is indeed a relationship between demography and inflation – while old-age dependents are deflationary, young dependents seem to be rather inflationary. This result should motivate further research.

This area is still underexploited and needs further research. Not only the impact of demographic variables on inflation rate is to be analyzed. Another still not enough addressed problem is the impact of ageing on the conduct of monetary policy, as demography as a driver of inflation may be relevant for monetary policy makers in the near future. The macroeconomic policy framework may therefore need to be revisited in the future. Demographic changes are not only one of the most important long-term challenges for the economy. They also can be relatively well predicted. This may be the reason why the demographic impact of inflation probably could be taken into account in monetary policy decisions.

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