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POPULATION DEPENDENCY AND INFLATION: A STUDY OF HIGH- AND UPPER-MIDDLE-INCOME COUNTRIES

Researchers often study whether demographic change brings about inflationary tendencies in recent years. The decrease in the population at active working age and the dependency ratio that arises because of the increasing old age show an area where there is no consensus on whether it causes an inflationary trend. In this context, we examined the trend of the young population dependency ratio, which represents the population aging and demographic change, and the tendency of the elderly population dependency ratio to affect inflation. The study conducted on 29 Upper Middle and High Income country economies in the period covering 1980-2020 used panel cointegration, panel ARDL and panel causality analysis methods. The main findings got from the study reveal that the elderly population dependency ratio has a deflationary effect in the short term, and the young population dependency has an inflationary effect in the long term.

When examining the empirical studies in the literature, findings that show that population aging often leads to a deflationary process come to the fore. In other words, the fact that the age distribution of the total population accumulated from the active working age population to the elderly population shows the existence of a negative correlation between aging and inflation.

Key words: population dependency, inflation, cointgration, panel data analysis, Dumitrescu-Hurlin panel causality.

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Халықтың тәуелділігі және инфляция: табысы жоғары және орташа деңгейден жоғары елдерді зерттеу

Соңғы жылдары зерттеушілер демографиялық өзгерістердің инфляциялық тенденцияларға әкелетінін жиі зерттеді. Белсенді еңбекке қабілетті жастағы халық санының азаюы және қарттықтың ұлғаюынан туындайтын асырауындағы адамдардың коэффициенті бұл инфляциялық тенденцияны тудыратыны туралы консенсус жоқ аймақты көрсетеді. Бұл тұрғыда біз халықтың қартаюы мен демографиялық өзгерістерді көрсететін жас халықтың тәуелділік коэффициентінің тенденциясын және егде жастағы халықтың тәуелділік коэффициентінің инфляцияға әсер ету тенденциясын зерттедік. 1980-2020 жылдарды қамтитын орташа және жоғары кірісі бар 29 елде жүргізілген зерттеу панельдік коинтеграция, ARDL панелі және себеп-салдарлық панельдік талдау әдістері қолданылды. Зерттеу нәтижесінде алынған негізгі нәтижелер егде жастағы халықтың тәуелділік коэффициенті қысқа мерзімді перспективада дефляциялық әсер ететінін, ал жас халықтың тәуелділігі ұзақ мерзімді перспективада инфляциялық әсер ететінін көрсетті.

Әдебиеттегі эмпирикалық мәліметтерді зерттеу кезінде халықтың қартаюы көбінесе дефляция процесіне әкелетінін көрсететін тұжырымдар бірінші орынға шығады. Басқаша айтқанда, белсенді еңбекке қабілетті жастағы популяциядан егде жастағы Халыққа дейін жинақталған жалпы халықтың жасына қарай таралуы қартаю мен инфляция арасында теріс корреляцияның бар екенін көрсетті.

Түйін сөздер: демографиялық тәуелділік, инфляция, коинтеграция, деректерді панельдік талдау, Думитреску-Херлин панелінің себеп-салдарлық байланысы.

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Зависимость населения и инфляция: исследование стран с высоким и выше среднего уровнем дохода

Исследователи в последние годы часто изучают, приводят ли демографические изменения к инфляционным тенденциям. Сокращение численности населения в активном трудоспособном возрасте и коэффициент иждивенцев, возникающий из-за увеличения пожилого возраста, указывают на область, в которой нет единого мнения о том, вызывает ли это инфляционную тенденцию. В этом контексте мы изучили тенденцию коэффициента иждивенчества молодого населения, который отражает старение населения и демографические изменения, и тенденцию коэффициента иждивенчества пожилого населения который влиять на инфляцию. В исследовании, проведенном в 29 странах с доходами выше среднего и с высоким уровнем дохода в период, охватывающий 1980-2020 годы, использовались методы панельной коинтеграции, панельного ARDL и панельного анализа причинно-следственных связей. Основные выводы, полученные в результате исследования, показывают, что коэффициент зависимости пожилого населения оказывает дефляционный эффект в краткосрочной перспективе, а коэффициент зависимость молодого населения оказывает инфляционный эффект в долгосрочной перспективе.

При изучении эмпирических исследований в литературе на первый план выходят выводы, которые показывают, что старение населения часто приводит к дефляционному процессу. Другими словами, тот факт, что возрастное распределение общей численности населения, накопленное от населения активного трудоспособного возраста до населения пожилого возраста, показывает существование отрицательной корреляции между старением и инфляцией.

Ключевые слова: демографическая зависимость, инфляция, коинтеграция, панельный анализ данных, причинно-следственная связь панели Думитреску-Херлина.

Introduction

The decrease in the rate of population growth and the aging of the working population are two of the major challenges confronting both developed and developing countries in recent times. Demographic change, which is defined as transformations in the population structure, affects the labor market, the size of the active and working population, public spending, taxation, investment, consumption and savings decisions of economic units in both the short and long run, with its dynamic structure (Broniatowska, 2019). Changes in the population age structure can cause profound and lasting impacts on the economy, with the intensity of these effects becoming increasingly pronounced as the populations age. In this context, the reflection of demographic changes on macroeconomic variables is one of the most important socio-economic arguments that policymakers should consider when planning policies for the future.

The size of economic growth varies according to the different investment and savings decisions of each age group. Young people will invest more in health and education, older people will need health care and retirement income, and adults will have labor and savings. In this context, the active working-age population comprising adults includes young people who consume more than they produce, as well as individuals with higher economic output and savings than the elderly (Sundman, 2011). In line with Sundman's view, in countries where inflation rates are low or the increase in inflation rates is slow, as the age level of the total population rises, economic units save. Analysis conducted based on the intersecting generations theory reveals that economic agents save during their old age when they owe their youth, and they seldom deplete their savings when their income is unstable and move to a consumption level. The aging or decrease in population leads to changes in consumption habits. Upwards, they will prefer saving to consumption, and ultimately, while aggregate demand will decrease, inflation will remain at a lower level. Thus, the decrease in total demand will decrease the effective labor supply in the economy and increase the downward pressure on inflation (Yoon et al., 2014).

Significant population changes observed in the world population in recent years have made it more important that the long-term effects of demographic change are manageable and predictable. (Carvalho et al., 2016). In particular, the rapid decline in birth rates despite the increase in life expectancy and the almost no increase in the retirement age in most of the European Union countries in the last twenty to thirty years have led to significant changes in consumption and saving behaviors, making it necessary to review macroeconomic policies (Bobeica et al., 2017). The 2020 European Commission Report predicts that the European population will account for approximately 4% of the total world population by 2070. As the report states, they expected that the population over 65 will increase 10% by 2070 compared to 2019, hitting 30.3%, and the population over 80 will be at 13.2% for the same year. The expected decrease in the share of the active working population in the total population will cause the share of European Union countries in the total world GDP to decrease significantly (EU Commission, 2020). Experts expect that the rise in the number of people above 65 and 80 in the total population will cause higher inflation rates. We can understand the connection between demographic structure and inflation when we examine the difference between the number of goods and services produced by certain age groups and the number of goods and services they consume. An increase in consumption by a particular age group will lead to higher prices. Here, it looks like the inflation rate has a positive relationship with the growth of the dependent population of group members who are not of active working age, such as children, youth, and the elderly (Petersen and Lopez, 2019). The study examined the effect of demographic change on inflation in 29 upper middle-and upper income groups. After the introduction, we present the relevant literature in the second part. We present the data set following the literature review. In the fourth section, we describe the empirical methodology, and the empirical results are in the fifth section. The study's conclusion were included in the sixth chapter.

Literature Review

The literature has studied the relationship between demographic change and inflation many times, both theoretically and empirically. In particular, deflation processes, which result from both the global crisis and the consumption-savings paradox of developed countries such as Japan, have increased the interest in examining the effects of aging and population growth on inflation. When examining the empirical studies in the literature, findings that show that population aging often leads to a deflationary process come to the fore. In other words, the fact that the age distribution of the total population accumulated from the active working age population to the elderly population shows the existence of a negative correlation between aging and inflation. This correlation makes demographic change an important structural factor that defines macroeconomic relations. This context presents the current results of the relevant empirical literature within different country groups, different variables and analysis methods below.

Anderson et al. (2014) examined whether population aging creates a deflationary effect in the Japanese economy. The study, conducted on the IMF's globally integrated monetary model, analyzes the deflationary pressures in the Japanese economy resulting from falling growth rates and land prices, and population aging. The results of the study, which combines the current macroeconomic structure of the Japanese economy with future projections, show that aging creates deflationary pressure through relative price changes. Yoon et al. (2014) concluded that there is a positive relationship between population growth and inflation for the period of 1960-2013 for 30 OECD countries, but the relationship between demographic change and inflation becomes negative as the share of the elderly population in the total population increases. Juselius and Takats (2015) studied the effects of demographic change on inflation for 22 OECD countries from 1870 to 2016. The analysis reveals a statistically significant relationship between population age structure and low-frequency inflation. The authors argue that the inflationary pressure caused by the increasing share of the elderly in the population does not have a strong effect on reducing inflation because of the decreasing share of the youth in the population. Inoue et al. (2016) examined how the decline in birth rates and the increase in the aging rate of the total population will affect the goods and services markets and asset markets. The findings of the study, which sampled 23 developed countries, including leading Asian countries, because of panel data analysis, show that while the young age dependency ratio has a positive effect on both inflation and housing prices, the elderly dependency ratio has a negative effect on these variables. Liu and Westelius (2017) examined the effect of demographic change on total factor productivity and inflation in Japan. In their study of the years 1990-2007, the authors concluded that the increase in the population aging rate and the slowdown in population growth created a deflationary pressure on the Japanese economy, while the decrease in the active population reduced the total factor productivity. Vlandas (2017) examined the relationship between aging and inflation through electoral politics and institutions, different from the general approach of the literature. According to the study, which argues that aging leads to lower inflation rates, that the elderly population group is both dissatisfied with inflation and has a strong political position in the total population in countries with a higher rate of elderly forces political parties to follow lower inflation rates. With another approach, the study argues that the older population's dissatisfaction with inflation strengthens the possibility of punishing the political authority during the election period. The study empirically shows that there is a negative correlation between the elderly population ratio and inflation in a larger sample group comprising 21 developed economies and 175 countries, and the increase in the elderly population leads governments to pursue lower inflation. Broniatowska (2017) examines the connection between inflation and the age structure of the population, and whether the increasing old-age dependency ratio is associated with lower inflation for 32 OECD member countries between 1971 and 2015. The study, based on panel data analysis, argues that an increase in the dependency ratio will create lower inflation. Emphasizing that continued population aging will downward pressure inflation, the findings show similar results with some previous empirical studies that an increase in life expectancy will create a deflationary tendency. Andrews et al. (2018) studied the inflationary, deflationary and dis-inflationary trends within the different age groups of the population. The findings of the study, which covers 22 OECD countries for the period covering the years 1955-2010, show that the increase in the share of the age group of 80 years and older creates deflation. Han (2019) analyzed the effect of demographic changes observed in Hong Kong, Singapore and China economies on inflation for the period 1991-2016 with the VAR analysis method. The findings reveal that the increase in the young population is inflationary, while the increase in the elderly population has a dis-inflationary effect. Kalafatcılar and Özmen (2019) analyzed the demographic transition and inflation relationship over 14 developing countries, including Turkey, for the years 1995-2015. The study is based on the view that the demographic transition shapes the age structure of developing countries and causes great fluctuations between the working age and the dependent population. The study shows that the dependent population positively relates to inflationary pressures, while the working age population relates to deflationary pressures. Albuquerque et al. (2020) examined the relationship between population aging and inflation for 24 OECD countries in the years 1961-2014. The study used the panel cointegration method to analyze the long-term effects of inflation and the age structure of the population for the period under consideration. The findings show that there is a long-term cointegration relationship between inflation and the growth rates of young and middle-aged population groups. As the panel least squares estimates show, an increase in the younger working-age population reveals explicit inflationary pressure, while an increase in the older working-age population reveals the existence of lagged inflationary pressure. The authors argue that the decrease in the working-age population and the high aging trend of the population create an inflationary situation. Kaygısız and Ezanoğlu (2021) examined the effect of demographic change on inflation using OLS and GMM panel data analysis techniques for 23 emerging economy countries (they performed the analysis on 18 country groups because of the imbalance of the data set) for the period 1995-2017. The results got by the authors are that the increase in the rate of the young population in the total population decreases inflation, while the elderly population increases inflation. Isa (2021) investigated the relationship between inflation and demographic effects with a linear regression based on the Phillips curve for the period 1996-2016 over the sample of Japan. Findings from the study reveal that population aging creates inflationary pressure, while the decreasing population causes deflationary pressure. Mousavian et al. (2022) examined the effect of population aging on inflation in developed and developing countries in the period 2001-2018 using a panel data analysis method. The results got from the study show that population aging has a negative and significant effect on the inflation rate in both developing and developed country groups. Rahman (2022) examined the possible effects of active and elderly population on real GDP growth and inflation in Japan using ARDL and VECM analysis methods. In the study, the results got from the ARDL boundary test point to the existence of a cointegration relationship between the variables, while the VECM results emphasize that the elderly population has a counteracting effect on real GDP growth, and the active age population has an expanding effect on real GDP growth. He et al. (2022) examined the relationship between population aging, inflation, and economic growth in the People's Republic of China using the BVAR analysis method. In the study, which examines the period covering the years 1961-2020, the main results indicate that population aging has a negative effect on inflation and economic growth.

Data and Model

In this study, the effect of population aging on inflation between 1980 and 2020 was examined. The sample of the study covers 29 economies determined as upper income and high income according to the World Bank classification. The country and time period of the sampling were determined within the availability of data. These countries are presented in the appendix. The study, in which annual data is used, has a balanced panel structure. In the study, the inflation variable (INF, %) was taken as the annual rate of change in the consumer price index. Population dependency variables are defined in two different ways, similar to the studies of Juselius and Takats (2105) and Broniatowska (2017), based on the young population dependency ratio and the elderly population dependency ratio. The young population covers the age range of 0-14, the elderly population 65+ and the working age population 15-64. In the study, $(ADPY_{ij} = (n_{ij}^{young} / n_{ij}^{workingage}))$ was obtained by dividing the youth dependency ratio of the young population (0-14) by the population of working age. Similarly, the elderly population dependency ratio is $(ADPO_{ij} = (n_{ij}^{old} / n_{ij}^{workingage}))$ by dividing the elderly population by the working age population. In the study, the annual growth rate of real gross domestic product (GDP, %), base monetary growth rate (M, %) and trade openness (TOT, %) control variables were added to examine the relationship between population aging and inflation. All variables in the study were taken from the World Bank database.

The relationship between inflation, population aging and control variables was defined by the $INF = f(ADPO, ADPY, GDP, M, TO)$ function. Based on this function, the basic empirical model defining the relationship in question was constructed as in equation (1):

$$INF_{it} = \beta_{1i} + \beta_{2i} ADPO + \beta_{3i} ADPY + \beta_{4i} GDP + \beta_{5i} M + \beta_{6i} TO + \varepsilon_{it} \quad (1)$$

In model (1), i represents the country in the model, t represents the time dimension of each country, β_1 is constant parameter, $\beta_{2i}, \beta_{3i}, \beta_{4i}, \beta_{5i}, \beta_{6i}$ are the slope coefficients and ε_{it} is the error term.

Empirical Methodology

The first step in panel data analysis is to test the slope homogeneity of the series. The slope homogeneity test is ignored in the literature and it is assumed that the sample forming the panel has a homogeneous distribution. However, defining the distribution structures of the series in panel data analysis is important to determine the test procedure to be applied. For this reason, the slope homogeneity of the series forming the panel sample was tested via the delta and delta-adj tests developed by Pesaran and Yamagata (2008). In the method in which the cross-sectional distribution of the individual slopes of the countries forming the panel is used, the null hypothesis, which assumes that the slope coefficients are homogeneous, is compared with the alternative hypothesis, which assumes that the slope coefficients are not homogeneous. The results got present the distribution structure of the panel. After testing the slope homogeneity, the cross-sectional dependence was investigated for the individual series and the entire panel. Cross-sectional dependence is important in several ways. The cross-section dependency test allows to determine whether a shock that will occur in one subgroup of the sample under consideration will have the same effect on all subgroups whether the reflection of the said shock on the subgroups differs. The cross-section dependence is important in the selection of the unit root test to apply to the series. The stationarity of the series should be investigated with first generation unit root tests with cross-sectional dependence, and second generation unit root tests if there is no cross-sectional dependence. In this direction, the cross-section dependence of the individual data of the countries and the whole panel was investigated with the Breusch-Pagan Lagrange Multiplier (LM), Bias-corrected scaled LM and Pesaran cross section dependence (CD) tests (Kaya, 2022:224). After the slope homogeneity and cross-sectional dependence tests, the stationarity of the series was investigated by second generation unit root tests. There are many unit root tests in the literature that allow unit root testing under cross-sectional dependence. The most used of these tests are Levin et al. (2002) and Im et al. (2003). These tests produce erroneous results due to cross-sectional dependence and slope homogeneity (Voumik and Akter, 2022). For this reason, in the study, cross-sectional augmented IPS (CIPS) and covariate-augmented Dickey Fuller (CADF) test methods, which are second generation unit root tests, were used to determine the stationarity of the series under cross-sectional dependence and slope heterogeneity. The CADF test is calculated with the help of the cross-sectional averages of the delayed values of the ADF regressions and the model in which the first differences of the individual series are included. In the CADF unit root test, the difference between cross-section and time dimensions is not significant, and the test produces consistent results under T>N or N>T conditions (Pesaran, 2007). After determining the degree of stationarity of the series, whether the series move together in the long run was examined with the Westerlund (2005) cointegration test. Westerlund (2005) cointegration test allows to investigate the cointegration relationship in cross-section dependence and slope heterogeneous panel data models. Westerlund (2005) investigates the existence of a cointegration relationship by testing whether the series in the panel has their own error correction, under the assumption that the error terms show an asymptotic distribution. Under the condition that the series are stationary of the same order, the cointegration relationship is tested by estimating the equation in equation (5) using the least squares method:

$$\Delta y_{it} = \delta_i^{'} d_t + \alpha_i y_{i,t-j} + \lambda_i^{'} x_{i,t-1} + \sum_{j=0}^{p_i} \gamma_i^{'} \Delta x_{i,t-j} + \sum_{j=1}^{p_i} \alpha_i^{'} \Delta y_{i,t-j} + \varepsilon_{it} \qquad (2)$$

In equation (2), $d_t = (1,t)^{'}$ is the deterministic components, $\delta_i = (\delta_{1i}, \delta_{2i})^{'}$ is related parameters vector and α_i error correction parameter. In the Westerlund cointegration test four different panel cointegration test statistics (G_a, G_t, P_a ve P_t) depending on the $\hat{\alpha}_i$ estimation values. G_a ve G_t test statistics define group mean test statistics, while P_a ve P_t test statistics define panel cointegration statistics for the whole panel. In this context, the mean test statistics for the group are established using $G_a = \frac{1}{N}\sum_{i=1}^{N}\frac{T\hat{\alpha}_i}{\hat{\alpha}_i(1)}$ and $G_t = \frac{1}{N}\sum_{i=1}^{N}\frac{\hat{\alpha}_i}{SE(\hat{\alpha}_i)}$, whereas the panel cointegration test statistics are calculated through $P_t = \frac{\hat{\alpha}}{SH(\hat{\alpha})}$ and $P_a = T\hat{\alpha}$ equations (Westerlund, 2007).

After the cointegration test, the short- and long-run relationship between the series was investigated by the ARDL-PMG method developed by Pesaran et al. (2001). The ARDL method establishes a long-term relationship between the series determined to be stationary at different degrees. The ARDL model allows the investigation of the long-term cointegration relationship in models in which the variables are I (0), I (1) or both. Including the lag length in the model in both internal and external variables in the ARDL method eliminates the internality problems and provides consistent estimations (Pesaran et al., 2001). ARDL, ARDL-PMG and ARDL-MG techniques are used to estimate the panel. The PMG technique is an advancement of the MG technique. The MG method assumes that the slope coefficients and error variance are heterogeneous for the entire sample, both in the short and long run. Taking this assumption into account, the mean values of slope coefficients and slope variance are used for each country in the sample in the estimation process. The PMG method, unlike the MG method, shows that the long-term coefficients are homogeneous for each country, but the heterogeneous structure should be considered when calculating the short-term coefficients. The most suitable technique among PMG and MG techniques is determined according to the Hausman homogeneity test results. When the long-term parameters of the model are heterogeneous, MG is the most suitable approach and if homogeneity exists, the PMG technique will be more appropriate (Attiaoui and Baufateh, 2019).

The ARDL (p, q) model where the dependent variable is INF and the explanatory variables ADPY, ADPO, GDP, M and TO is defined as in equation (3):

$$\Delta INF_{it} = \alpha_{1i} + \beta_{1i} INF_{it-1} + \beta_{2i} ADPO_{it-1} + \beta_{3i} ADPY_{it-1} + \beta_{4i} GDP_{it-1} + \beta_{5i} M_{it-1} + \beta_{6i} TO_{it-1} \quad (3)$$
$$+ \sum_{j=1}^{p} \delta_{1i} \Delta INF_{it-j} + \sum_{i=0}^{q} \delta_{2i} \Delta ADPO_{it-j} + \sum_{i=0}^{q} \delta_{3i} \Delta ADPY_{it-j} + \sum_{i=0}^{q} \delta_{4i} \Delta GDP_{it-j} + \sum_{i=0}^{q} \delta_{5i} \Delta M_{it-j} + \sum_{i=0}^{q} \delta_{6i} \Delta TO_{it-j} + \varepsilon_{1it}$$

In equation (3), p and q the optimal lags of the model, α_{1i} is constant term, $\beta_{1i} \ldots \beta_{6i}$ are the long term coefficients, $\delta_1, ..., \delta_6$ are the error correction dynamics, ε_t is the white noise error correction and Δ is the lag operator of the dependent and independent variables. Optimal lag lengths in ARDL model estimation were determined according to Akaike Information Criteria (AIC). The cointegration relationship in the ARDL model is tested by comparing the null hypothesis of $H_0 : \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = 0$, which states that there is no cointegration relationship between the series, and the $H_1 : \delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq \delta_5 \neq \delta_6 \neq 0$ hypothesis, which states that there is a cointegration relationship for at least one (Pesaran et al., 2001). After determining the long-term relationships between the variables, the short-term relationship between the variables is estimated with the error correction model (ECT). The ECT model is calculated over the lagged value of the residues got from the long-term relationship. The ECT model is defined by equation (4):

$$\Delta INF_{it} = \alpha_{1i} + \sum_{j=1}^{p-1} \gamma_{1i} \Delta INF_{it-j} + \sum_{i=0}^{q-1} \gamma_{2i} \Delta ADPO_{it-j} + \sum_{i=0}^{q-1} \gamma_{3i} \Delta ADPY_{it-j} + \sum_{i=0}^{q-1} \gamma_{4i} \Delta GDP_{it-j} + \sum_{i=0}^{q-1} \gamma_{5i} \Delta M_{it-j} + \sum_{i=0}^{q-1} \gamma_{6i} \Delta TO_{it-j} + \mu_{1i} ECT_{1,it} + \varepsilon_{lit} \quad (4)$$

Equation (4) (l={1,2,3,4,5,6}) defines the residues got from the long-term results. ε_{lit} is independent and normally distributed with zero mean and constant variance. The $ECT_{1,it}$ term (l={1,2,3,4,5,6}) is the error term defined by the long-run relationship. The μ_{1i} parameter shows the rate at which the short-term imbalance is adjusted to the long-term equilibrium level (Attiaoui et al., 2017). In the ARDL model, the term $ECT_{1,it}$ is expected to have a negative sign and be statistically significant.

Finally, the Dumitrescu-Hurlin (2012) panel causality test was used to study the long- and short-term connection between the series. Dumitrescu-Hurlin (2012) panel causality test is an improved version of Granger causality test. Considering panel heterogeneity and cross-section dependence, Dumitrescu-Hurlin (2012) panel causality test tests the effects of past observations of a variable defined as x on current observations of variable y, as in Granger causality analysis. The results got for the hypotheses that there is no Granger causality relationship between the variables and that there is a Granger causality relationship between the variables are compared with the Wald statistical values and the causality relationship between the variables is tested. Dumitrescu-Hurlin panel causality test, which allows to investigate causality over stationary series, k is represents the optimal lag number, α is the constant parameter, β and γ are the coefficient vectors, and ε is the error term. Equation (5) of the Dumitrescu-Hurlin panel causality test is formed as in the equation:

$$y_{i,t} = \alpha_i + \sum_{k=1}^{K} \beta_{ik} y_{i,t-k} + \sum_{k=1}^{K} \gamma_{ik} x_{i,t-k} + \varepsilon_{i,t} \quad (5)$$

In the DH panel causality analysis, homogeneous and heterogeneous structures are tested through equation. Under the assumption that the null hypothesis is homogeneous and the alternative hypothesis is heterogeneous. By comparing the statistical results from the analysis to the F statistical values, the causality relationship between the variables can be determined.

Empirical Results

Table 1 shows the results of the panel slope homogeneity test. The null hypothesis slope coefficient is homogeneous and the alternative hypothesis slope coefficient is not homogeneous (heterogeneous). Delta and delta-adj results show that the null hypothesis claiming that the panel is homogeneous is rejected at the 1% significance level and that the panel is heterogeneous.

Table 2 shows the panel cross-section dependency test results. The null hypothesis that determined the cross-sectional dependence was that there is no cross-section dependency, and the alternative hypothesis was that there is a cross-section dependency. According to the test results got, the null hypothesis stating that there is no cross-sectional dependence for the individual series and the entire panel was rejected at the 1% significance level, and it was concluded that there was a cross-sectional dependence between the countries that made up the panel.

Table 1 – Slope Homogeneity Test Results

	Statistics	**p-value**
$\hat{\Delta}$	27.594	0.0000
$\hat{\Delta}_{adj}$	30.302	0.0000

Table 2 – Cross-Sectional Dependence Test Results

	INF	ADPO	ADPY	GDP	M	TO	PANEL
Breusch-Pagan LM	4076.05*** (0.000)	11181.64*** (0.000)	12532.49*** (0.000)	1813.08*** (0.000)	1278.74*** (0.000)	3876.65*** (0.000)	1189*** (0.000)
Bias-corrected scaled LM	128.43*** (0.000)	377.78*** (0.000)	425.19*** (0.000)	49.01*** (0.000)	30.26*** (0.000)	121.43*** (0.000)	84.13*** (0.000)
Pesaran CD	56.44*** (0.000)	80.99*** (0.000)	109.42*** (0.000)	34.82*** (0.000)	20.79*** (0.000)	24.59*** (0.000)	17.47*** (0.000)
***, ** and * show statistically significance at 1%, 5% and 10% level, respectively. p-values are shown in parentheses.							

Tables 3a and 3b present the CIPS and CADF unit root test results. As seen in Tables 3a and 3b, all variables were found to be stationary as a result of both tests, except for the TO variable. The variable TO becomes stationary at the first difference. In the light of the findings, it was determined that some series became stationary at the (0) level and some series became stationary at the (1) level, but none of the series were stationary at the (2) level.

Table 3 – CIPS and CADF Unit Root Test Results
Table 3a – CIPS Test Results

Variables	**Level**				**First Difference**			
	Without trend		With trend		Without trend		With trend	
	Zt-bar	p-value	Zt-bar	p-value	Zt-bar	p-value	Zt-bar	p-value
INF	-13.015	0.000***	-10.802	0.000***	-21.621	0.000***	-19.941	0.000***
ADPO	-5.654	0.000***	-5.326	0.000***	-2.476	0.007***	0.617	0.731
ADPY	-7.677	0.021**	-3.879	0.000***	-3.286	0.000***	4.506	0.000***
GDP	-14.915	0.000***	-14.176	0.000***	-18.617	0.000***	-16.355	0.000***
M	-15.815	0.000***	-16.436	0.000***	-17.062	0.000***	-14.513	0.000***
TO	1.723	0.958	2.288	0.989	-7.145	0.000***	-5.696	0.000***

Table 3b – CADF Test Results

Variables	Level			First Difference		
	t-bar	Z[t-bar]	p-value	t-bar	Z[t-bar]	p-value
INF	--3.593	-10.442	0.000***	-5.544	--21.621	0.000***
ADPO	-2.757	-5.654	0.000***	--2.202	-2.476	0.007**
ADPY	--3.110	-10.523	0.000***	-1.820	0.506	0.694
GDP	-3.607	-7.200	0.000***	-5.749	-22.794	0.000***
M	-2.305	-3.064	0.001***	-5.785	-23.000	0.000***
TO	-1.513	1.474	0.930	-3.017	-7.145	0.000***
***, ** and * show statistically significance at 1%, 5% and 10% level, respectively						

In the CIPS test, the critical values were compared with the table values determined as -2.08, -2.16 and -2.3 for 10%, 5% and 1% significance levels, respectively.

After the stationarity levels of the series were determined and the non-stationary series were made stationary by taking the difference, the long-term cointegration relationship between the series was investigated. The results got from the study in which the Westerlund (2007) cointegration test was applied are shown in Table 4. Westerlund recommends using bootstrap values with cross-section dependency. For this reason, the cointegration test was iterated with 100 bootstraps. G_t and G_a group panel cointegration test results, P_a and P_t panel cointegration results. In the cointegration test results, three of the four test statistics were significant. This result shows that panel cointegration tests have a long-term cointegration relationship on the sample, while group cointegration tests show that there is a long-term cointegration relationship, but this relationship is in a weak form. The cointegration test applied in this context reveals that there is a long-term cointegration relationship between the variables.

Table 4 – Westerlund Cointegration Test Results

Statistic	Value	Z-value	P-value
Gt	-12.654	-0.044	0.082*
Ga	-5.648	6.094	1.000
Pt	-34.432	-20.032	0.000***
Pa	-37.772	-17.097	0.000****

***,** and * show statistically significance at 1%,5% and 10% level, respectively.

The long-term and short-term relationship between the variables was determined using PMG and MG estimators. According to the PMG long and short-term estimation results presented in Table 5, ADPY, M and TO variables have positive signs in the long term. A 1% increase in the youth dependency ratio increases inflation by 0.0939 percent in the long run. While a 1% increase in money supply increases inflation by 0.1130 percent in the long run, a one-unit increase in openness increases inflation by 0.3636 percent in the long run. When the short-term relationship of the variables is examined, it is seen that the young population dependency ratio is statistically insignificant in the short-term. ADPO and GDP variables were statistically significant in the short run. In the light of these findings, a 1% increase in the elderly population dependency ratio reduces inflation by 24,040 percent in the short term, while a 1% increase in national income reduces inflation by 0.0501 percent. When the long- and short-term estimation results of the MG model are evaluated, it is concluded that the GDP and M variables are statistically significant at the 1% significance level in the long term, while the other variables are statistically insignificant. According to this result, a 1% increase in national income in the long run will reduce inflation by 1.7541 percent. A 1% increase in money supply will increase inflation by 1.2688. When the short-term estimation results of the MG model are evaluated, it is seen that the ADPY, GDP, M and TO variables are statistically significant. A

1% increase in the young population dependency ratio in the short term increases inflation by 1.9493. Similar to the long-term results, a 1% increase in national income will decrease inflation by 1.7703 percent, and a 1% increase in money supply will increase inflation by 0.9216 percent. When we look at the openness rate, a 1% change in openness will reduce inflation by 0.2982 percent in the short run. When the short-term error correction coefficient results in PMG and MG models are examined, it is seen that the $ECT_{1,it}$ parameter is negative and statistically significant at the 1% significance level in both models. Its value was founded to -0.4462 in the PMG analysis. This result shows that a one-unit deviation (1/-0.4462=2.24) that will occur in the short term will be corrected by 44% in the long term and converge to the balance again after approximately 2.3 periods. Similarly, the $ECT_{1,it}$ value found as 0.0486 in the MG analysis shows that a one-unit deviation (1/-0.0486 = 20.57) in the short-term will be corrected by 0.4% each year in the long-term and will converge to the balance again after approximately 20 periods. Hausman test results applied to find the most suitable estimator between PMG and MG methods indicate that MG model estimations are stronger. This finding is consistent with the fact that the long-term parameters of the model are heterogeneous.

Table 5 – PMG and MG Estimation Results

	PMG				MG			
Variables	Coeff. Std. Error		z-Statistic	p-value	Coeff. Std. Error		z-Statistic	p-value
Long-Run Results								
ADPO	0. 0088	0.0278	0.32	0.752	0.2399	0.2758	0.87	0.384
ADPY	0.0939	0.0322	2.91	0.004***	0.0105	0.0649	0.16	0.871
GDP	0.0498	0.0616	0.81	0.419	-1.7541	0.2192	-8.00	0.000***
M	0.1130	0.0207	5.46	0.000***	1.2688	0.0040	316.40	0.000***
TO	0.3636	0.0403	9.01	0.000***	0.1411	0.1232	1.15	0.252
Short-Run Results								
ECT (-1)	-0.4462	0.0442	-10.09	0.000***	-1.7748	0.0486	-36.51	0.000***
D.ADPO	-24.040	12.8612	-1.87	0.062*	-10.079	7.9856	-1.26	0.207
D.ADPY	0.6033	2.4189	0.25	0.803	4.0751	1.9493	2.09	0.037**
D.GDP	-0.0501	0.2963	-1.69	0.091*	-1.7703	-0.3217	5.50	0.000***
D.M	0.0391	0.0412	0.95	0.342	0.9216	0.0568	-16.21	0.000***
D.TO	-0.7701	0.7622	-1.01	0.312	-0.2982	0.1538	-1.94	0.053*
Constant	4.4214	3.6211	1.22	0.222	-8.4732	8.9834	-0.94	0.346
Hausman Test								
H_0: PMG				0.137				
H_1: MG								

***, ** and * show statistically significance at 1%, 5% and 10% level, respectively. D defines the difference operator.

After looking at both long- and short-term estimations, the Dumitrescu-Hurlin panel causality test was used to assess the relationship between the variables. The causality analysis was performed for three lags. In the DH analysis, the null hypothesis was defined as there is no Granger causality relationship between the variables, and the alternative hypothesis was defined as there is a Granger causality relationship between the variables. Probability values got as a result of the test were compared with 1%, 5% and 10% significance levels. Accordingly, the null hypothesis suggesting that there is no causality relationship from ADPO, ADPY, GDP and M variables to inflation at all three lag values was rejected at 1% significance level. The null hypothesis, which claims that there is no causality relationship from the TO variable to inflation, is rejected in the model estimated only for the first lag at 1% significance level. Considering the relationship between population dependency and inflation, which is the main subject of the study, it has been determined that the results of the DH causality test support the results of PMG and MG.

Table 6 – Dumitrescu-Hurlin Panel Causality Test Results

Null Hyphotesis	p-value(lag=1)	p-value(lag=2)	p-value(lag=3)
ADPO ≠> INF	3.E-12***	6.E-11***	2.E-13***
ADPY ≠> INF	9.E-11***	0.0000***	1.E-13***
GDP ≠> INF	0.0000***	0.0000***	0.0000***
M ≠> INF	0.0000***	0.0000***	0.0000***
TO ≠> INF	2.E-09***	0.6176	0.4602

***,** and * indicate rejection of the null hyphotesis of no Granger causality at the 1%,5% and 10% significance level, respectively. Causality analysis was estimated for three lags.

Conclusion

In this study, the effect of population aging on inflation was investigated using annual data for the 1980-2020 period. Westerlund (2007) cointegration test, panel ARDL model and Dumitrescu-Hurlin (2012) panel causality tests were applied in the study conducted for 29 countries classified as upper middle income and high income by the World Bank. In the study, first, slope homogeneity was determined, then it was examined whether there was cross-sectional dependence for individual country groups and the whole panel. Because of the heterogeneity of the panel structure and cross-section dependence, second generation unit root tests were applied and whether there was a long-term relationship between the series that were stationary at different degrees was investigated by cointegration test. After detecting long-term cointegration between the series, long- and short-term predictions were examined by ARDL-PMG and ARDL-MG methods. After determining the long- and short-term relationships between the variables, the causality relationship between the variables was investigated.

In the results of the cointegration test applied in the study, we found that there was strong cointegration in the entire panel sample and weak cointegration between the groups. The long-term results of the ARDL-PMG model, which was applied after it was determined that the variables act together in the long-term results show that the young population dependency affects inflation positively in the long run, while the elderly population dependency affects inflation negatively in the short run. These results are compatible with Yoon et al. (2014), Juselius and Takats (2015), Inoue (2016), Liu and Vestelius (2017), Vlandas (2017), Broniatowska (2017), Andrews (2018), He (2022), Mousavian (2022)'s conclusions. The ARDL-MG model results show that the elderly population dependency has no effect on inflation in the long run, while the increase in the young population dependency ratio has a positive effect on inflation in the short run. The results pointing to the opposite result of the ARDL-MG model in the short term are in line with the studies of Andrews (2018), Han (2019), Albuertuque (2020), Rahman (2022). When the optimality of PMG and MG model results was evaluated according to the Hausman test result, it was found that the PMG estimator produced more consistent results compared with the MG estimator. Therefore, in this study examining the relationship between population dependence and inflation, the heterogeneity of the panel structure, the stronger effect of the panel cointegration relationship as a result of the Westerlund cointegration test, and the Hausman test results reveal the PMG model is more consistent. Therefore, the validity of the results for PMG analysis is considered being higher. In this context, the findings got from the long- and short-term results show that the dependence on the young population is inflationary in the long term, and that the dependence on the elderly population is deflationary in the short term. The signs of the control variables used in the model estimation were compatible with the theory. According to the results of the control variables, the increase in the money supply affects the inflation positively. Openness affects inflation positively in the long run and negatively in the short run, as stated in the literature. Finally, the causality relationship between the variables was examined in the study. The causality relationship results show that there is a Granger causality relationship at all three levels of lag, from the young population dependency ratio and the elderly population dependency ratio to inflation. When the control variables are evaluated, it has been determined that there is a Granger causality relationship from money supply and national income to inflation at all three lag levels, while there is a Granger causality relationship from the openness variable to inflation only in the first lag.

Appendix
List of countries examined in the study

Upper-Middle Income Countries				High-Income Countries		
Algeria	Botswana	Costa Rica	Dominican Rep.	Australia	Chilie	Denmark
Ecuador	Fiji	Guatemala	Gabon	Japan	Norway	Korea, Rep.
Jamaica	Jordan	Malaysia	Mauritus	Sweden	United Kingdom	United States
Mexico	Paraguay	Peru	South Africa	Uruguay		
SriLanka	Thailand	Turkey				

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