JOURNAL OF ECONOMIC DEVELOPMENT
Volume 50, Number 1, March 2025

THE EFFECT OF DEMOGRAPHY ON INFLATION IN DEVELOPING COUNTRIES OF ASIA: EMPIRICAL EVIDENCE*

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The United Nations (2022b) predicts that between 2022 and 2050, the share of the elderly population (65 and above) in the Asian region will double. An aging society would create macroeconomic challenges, and several studies, mainly for developed countries, have negatively linked aging with inflation. Given the absence of research in developing countries, especially Asian countries, we attempt to estimate the impact of demography on inflation in Asian developing countries between 1995 and 2019. Our results indicate that the young (0-14) and old populations (70 and above) are deflationary, while working-age populations and very young retirees (65-69) are inflationary. Our findings favor the political economy hypothesis, i.e., age groups influence inflation based on preference. The findings are robust to adding several macroeconomic controls. Our results suggest that the central bank should follow stringent inflation targeting to mitigate the adverse effects of inflation on economic growth and aging.

Keywords: Inflation, Demography, Developing Countries of Asia, Political Economy Hypothesis, Inflation Targeting
JEL Classification: E31, E52, J11

1. INTRODUCTION

Since the early 1990s,[1] the relationship between demography and inflation has been gaining increasing attention in the academic and policy-making discourses, possibly due to the coincidence of the low inflation with demographic-related changes like the

* Authors would like to appreciate Dr. Mikael Juselius for sharing his Stata code used in his paper and advice related to polynomial estimation technique.

[1] One of the earliest studies was conducted by McMillan and Baesel (1990) for the United States of America and emphasized that demography is a good predictor of trend inflation.

increase in the retired elderly population (baby boomers) in developed countries (Juselius and Takáts, 2021; Goodhart et al., 2015). Several studies, such as Nagarajan et al. (2021), Harper and Leeson (2008), and Yong and Saito (2012), argued that a rise in longevity and a fall in birth rates helped the speed of aging. However, the relationship between demography and inflation is debated. Bullard et al. (2012) highlighted that the old population has low inflation preferences. As the age of median voter increases, resulting from the rising share of the old in the total population, the government adopts policy measures for reducing inflation, thus creating deflationary pressure. Likewise, Katagiri et al. (2020) argued that due to an unexpected rise in life expectancy, the old population falls short of savings in their extended post-retirement period, and the government suppresses inflation to protect the fixed income of the old population. Both Bullard et al. (2012) and Katagiri et al. (2020) highlighted that political channels mediate the relationship between demography and inflation. Contrary to previous studies, Juselius and Takáts (2021) argued that the economic channel mediates the relationship between demography and inflation. Based on the analysis of 22 Organisation of Economic Cooperation and Development (OECD) countries between 1870 and 2016, it concluded that increasing dependent population (old and young) creates inflationary pressure due to the interest rate misalignment, that is, the delayed policy response of central banks to the slow-moving demography-induced changes in natural interest rates. This lingering debate and lack of consensus underscore the need for further research to validate the demography-inflation relationship.

The rate at which population aging is increasing is much higher in developing countries than in developed countries (Lee, 2002; Nagarajan et al., 2017; United Nations, 2022b); therefore, the demographic shift is not only limited to developed countries but also developing countries. The demographic change in the continent of Asia is also significant. According to the United Nations (2022b), the elderly population (65 and above) in Eastern and South-Eastern Asia is predicted to double from 12.7% in 2022 to 25.7% by 2050, and in Central and Southern Asia, a similar trend is expected with an increase from 6.4% to 13.4%. These staggering numbers reflect the extent to which aging is likely to create macroeconomic challenges, including a drag on economic growth in developing Asian countries. It also creates a fiscal burden through high public expenditure on health and pensions. In the face of limited financial resources, governments in developing countries may find it challenging to allocate resources to manage the expenditures arising from the increasing elderly population. The rising old-age population in developing countries of Asia motivates us to study the effect of demography on inflation.

The extant literature on the relationship between demography and inflation is highly skewed toward developed countries. Lindh and Malmberg (1998, 2000) established the link between net consumers (young and old) group and inflationary pressure, whereas Yoon et al. (2018) and Papapetrou and Tsalaporta (2020) highlighted the relationship of working-age and old population with deflationary pressure in the OECD countries. Other studies explored the relationship among old-age dependency, young-age dependency, and inflation in OECD countries (Gajewski, 2015; Broniatowska, 2019), very old population and inflation in OECD countries (Andrews et al., 2018; de Albuquerque et al., 2020), growth of the working-age population and inflation in Euro area countries (Bobeica et al., 2017), between the old-age dependency ratio and inflation for the Economic and Monetary Union (EMU) of the European Union (Radulovic and Kostic, 2021), and old-age dependency and inflation in the context of Japan (Liu and Westelius, 2017; Isa, 2021). However, a very limited number of studies have been conducted in developing countries; for example, Antonova and Vymyatnina (2018) studied 21 emerging countries, Kaya and Uzun (2023) studied 29 upper-middle and high-income countries, and Kalafatcılar and Özmen (2021) studied 14 emerging countries to establish the relationship between inflation and demography. Ma and Tang (2023) provide generalized evidence of how young and old populations affect inflation in 125 countries. Moreover, Vlandas (2017) found a correlation between the elderly population and inflation by analyzing 21 developed countries with a sample of 175 countries.

The above literature review suggests a lack of evidence for the relationship between demography and inflation in the panel of Asian developing countries. A deep understanding of the demography-inflation relationship aids central banks in formulating well-informed and evidence-based monetary policy. Considering these, the present study exhibits the trends of key demographic variables, such as life expectancy, fertility rate, population growth, and share of different age groups between 1950 and 2100. We attempt to estimate the impact of demography on inflation in Asian developing countries between 1995 and 2019 by applying the population polynomial technique used by Juselius and Takáts (2021). The technique is useful in overcoming the collinearity issue among consecutive age groups. We find that young and old populations are broadly associated with deflation, while working-age populations and young retirees (65-69) are associated with inflation. The results are robust when adding several controls.

According to Juselius and Takáts (2021), demography can affect inflation in two ways. First, political channel: the inflation preference of each age group is different. The working-age population prefers high inflation to ensure economic activities and employment. At the same time, the old population prefers low inflation to secure the value of their savings and other fixed assets. The median age also changes when demographic changes occur, affecting inflation preference. If this channel is valid, there will be a positive relationship between the higher share of the working-age (also known as borrower cohorts) population and inflation but a negative association between the higher share of the old population (also known as a share of the lender or asset owner cohorts) and inflation. Second, economic channel or interest rate misalignment: the working-age population (net savers) drives down the natural interest rate, whereas the dependent population or net dissevers (young and old population) drives up the natural interest rate. However, central banks do not necessarily account for the changes in the natural rate of interest and may focus on other aspects like managing exchange rates. If this channel is valid, there will be a negative relationship between the working-age population and inflation but a positive relationship between the higher dependent population (young and old groups) and inflation. We find our result consistent with the political channel outlined by Juselius and Takáts (2021).

This paper is organized as follows. In Section 2, we review the demographic transition in Asia. Section 3 discusses the data and methodology used in this paper. In Section 4, we discuss the results. Moreover, in Section 5, we conclude.

2. ASIAN DEMOGRAPHICS:AN OVERVIEW

Although demographic-related changes are a global phenomenon, the demographic experience in Asia differs from that of other continents. For instance, when considering two crucial demographic indicators, i.e., fertility rate and life expectancy at birth between Asia and Europe,[2] data from the United Nations (2022a) reveals significant variation. Between 1950 and 2021, the fertility rate declined by 45% in Europe and 62.42% in Asia.[3] Similarly, during the same period, life expectancy at birth increased by 23% in Europe and 66.48% in Asia.[4] These changes in these indicators suggest substantial advancements in the health sector within Asia. The present study focuses on Asian countries, particularly those classified as developing countries within Asia.

Bloom and Williamson (1998) demonstrated demographic transition in broadly three phases; a high birth rate and death rate characterized the first phase. The second phase, or transition phase, has a lower death rate and birth rate, but the rate of decline in the death rate is more than the birth rate. In the third phase, the birth and death rates become stationary. The United Nations (2022a) data starts from 1950, so we do not observe a pre-transition stationary level. In addition to that, we also do not observe the post-transition stationary birth and death rate in Asian countries (Figure 1). The second demographic transition (for details, refer to Atoh et al., 2004) may explain the demographic changes taking place in Asia, which discusses several factors like changes in marital behavior, including a rise in cohabitation, extramarital births, and divorces, among others behind the rapid decline in fertility rate.

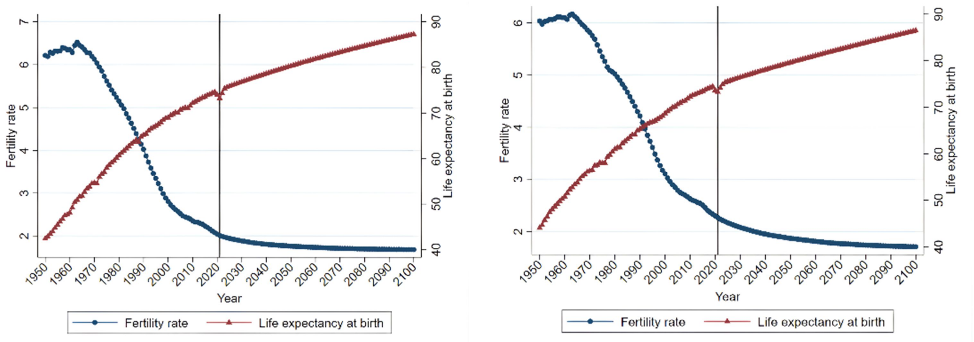
The fertility rate continuously declined and reached a replacement fertility level of 2.1 in 2018 for our sample (19 developing countries of Asia) and Asia as a whole (Figures 1a and 1b). However, the projections show a further decline in the coming decades. On the other hand, the life expectancy at birth has increased dramatically and is projected to increase further (Figures 1a and 1b). The decline in fertility rate and

[2] Europe is considered the oldest continent in the World (Bobeica et al., 2017).

[3] The drop in fertility between 1950 and 2021 is 62.40% in Asia, excluding Japan. This drop is 61.88% in Asia, excluding four developed countries of Asia, such as Israel, Japan, Singapore, and South Korea.

[4] The increase in life expectancy between 1950 and 2021 in Asia is 67.14%, excluding Japan. The increase in life expectancy in Asia is 66.40% when we exclude four developed countries of Asia.

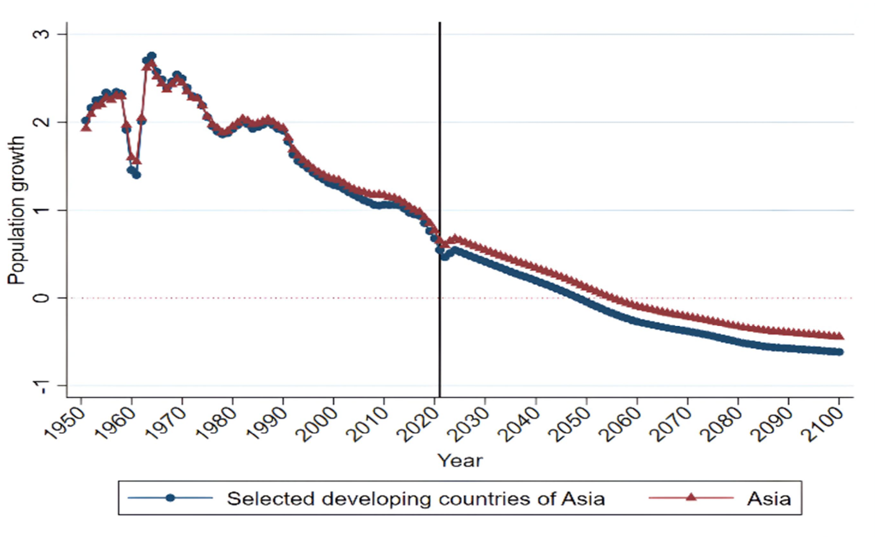
increase in life expectancy have opposite effects on population growth. The decline in fertility reduces population growth; on the other hand, the increase in life expectancy helps population growth. The population growth even becomes negative from 2049 onwards in our sample (Figure 2). However, population growth in Asia becomes negative after six years (from 2056 onwards) compared to our sample.



(a) Selected developing countries of Asia (b) Asia

Source: Authors' estimation using UN population prospects (2022 revision) data.

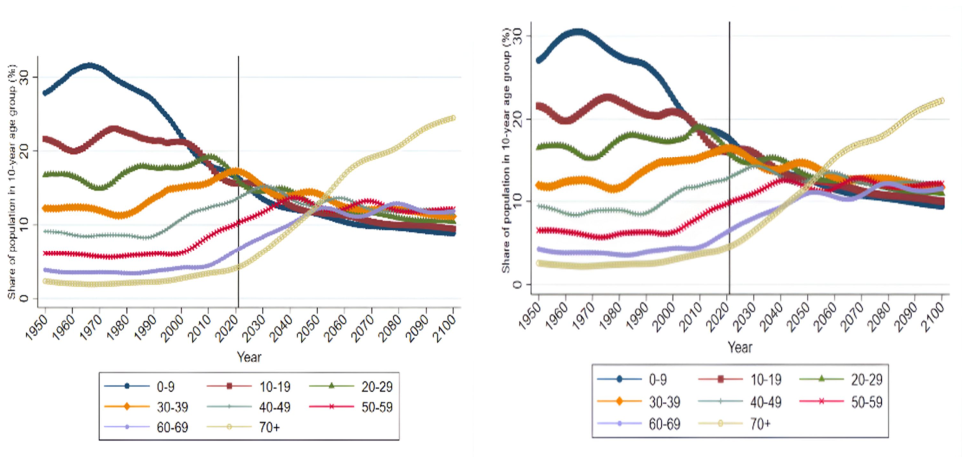
Figure 1. Fertility Rate and Life Expectancy at Birth from 1950-2100



Source: Authors' estimation using UN population prospects (2022 revision) data.

Figure 2. Population Growth Rate from 1950-2100

The fertility decline and life expectancy increase tilt the population distribution rightwards. Figure 3a illustrates four aspects of demographic structure in our sample: first, the share of 0-9 in the total population declined continuously from 27% in 1950 to 9% by 2100. Second, the share of 70+ in the total population increases from 2% in 1950 to 24% by 2100. Third, the share of 60-69 and 70+ combined in the total population exceeds the share of 0-9 and 10-19 in the total population in 2049. Fourth, the share of the combined population between 20 and 50 in the total population remains at its peak (57%) in 2018, then starts declining. A similar pattern can also be observed for overall Asia (Figure 3b). The changes in age structures decide the economic future of the nations; according to the life cycle hypothesis (Modigliani and Brumberg, 1954), different age groups have different savings and spending patterns. Guest and McDonald (2004) confirmed that demographic change causes variations in national savings in Asian countries. The aggregate demand in the economy also changes with demographic changes. For instance, in the case of the United Kingdom, Lührmann (2008) outlined that the spending power of different age groups mainly explains trends in aggregate consumer demand. The study also elucidated that intergenerational income redistribution shifts towards older age groups substantially affect aggregate demand.



(a) Selected developing countries of Asia (b) Asia

Source: Authors' estimation using UN population prospects (2022 revision) data.

Figure 3. The Trends of the Demographic Structure (1950-2100)

The change in demography that leads to an increase in the older population is also linked to changes in macroeconomic variables such as economic growth, per capita income, labor productivity, and real interest rate, housing prices, employment, among others (for detailed discussion, refer to Park et al., 2022; Acemoglu and Restrepo, 2022;

Carvalho et al., 2016; Ann and Park, 2022; Adegboye and Arodoye, 2023). The present study solely focuses on one macroeconomic variable, i.e., inflation, which is essential yet ignored in the case of developing countries of Asia.

3. DATA AND METHODOLOGY

3.1. Data

The study covers the periods between 1995 and 2019. As we are interested in analyzing the relationship between inflation and demography in the case of Asian developing countries, we dropped four developed countries[5] from the sample. We further dropped 25 Asian countries due to the irregular observations of our key variables (inflation and real interest rate). Finally, we select an unbalanced panel of 19 developing countries of Asian countries (refer to Table A1). The development status of these countries is identified based on the classifications of the International Monetary Fund (IMF) (IMF, 2022). The descriptive statistics of the variables used in the study are presented in Table 1.

The primary variable of interest is inflation. We retrieve data on inflation from the World Development Indicators database (WDI). Following Juselius and Takáts (2021), we truncate inflation observations at ±25% to deal with hyperinflationary or hyper-deflationary episodes, as keeping this can bias the estimates.[6] The second key variable of interest is demography, i.e., the age structures of the population, which we retrieve from the United Nations (2022a). Following Juselius and Takáts (2021), the total population (denoted as N_{it}, where i and t are countries and years, respectively) is divided into 17 five-year age cohorts (denoted as N_{kit}, where $k = 1,\dots,17$) and N_{kit} shows the number of people in each age cohorts: 0-4, 5-9, 10-14,..., 80+. The share of each cohort in the total population is denoted by n_{kit} (N_{kit}/N_{it}).

As macroeconomic controls, we use real interest rate, output gap, government debt, broad money growth, GDP growth, terms of trade, and industry employment. The selection of variables is motivated through the determinants of inflations from the Fisher Equation, New Keynesian Philips curve framework, Quantity Theory of Money (QTM), and previous literature (Juselius and Takáts, 2021; Kalafatcılar and Özmen, 2021; Antonova and Vymyatnina, 2018). We use the real interest rate extracted from WDI to

[5] There four developed countries in Asia as classified by IMF (2022) are Israel, Japan, Singapore, and South Korea.

[6] Following Juselius and Takáts (2021), we also remove observations that lie below 2.5 or above the 97.5 percentiles of all independent variables to deal with extreme values.

control the effects of the monetary policy.[7] We estimate the output gap,[8] for each country following Juselius and Takáts (2021) by applying Hodrick-Prescott filter[9] to the real GDP and measured as the deviation from the filtered trend. We collect data on government debt from the International Monetary Fund (IMF). Government debt can be crucial as a higher debt level may compel the government to print more money (Antonova and Vymyatnina, 2018), which may be inflationary.

Table 1. Descriptive Statistics

Variable	Description	Obs.	Mean	Std. dev.	Min.	Max.
Inflation	Change in consumer prices	424	4.60	3.56	-1.71	22.56
Population share (0-14)	Percentage share of the population aged 0 to 14 in total population	453	29.35	5.91	18.34	40.87
Population share (15-64)	Percentage share of the population aged 15 to 64 in total population	453	65.46	4.96	55.80	76.28
Population share (65 and above)	Percentage share of the population aged 65 and above in total population	453	5.05	2.1	1.68	10.96
Real interest rate	Lending interest rate adjusted for inflation	411	5.33	6.21	-13.17	29.71
Output gap	Estimated from log real GDP using HP filter	451	-0.00	0.04	-0.10	0.16
Government debt	Percentage share of GDP	399	46.03	22.95	4.64	114.8
GDP growth	Annual percentage growth	452	5.65	2.71	-2.37	13.57
Broad money growth	Annual percentage growth	445	15.35	9.02	0.23	43.00
Terms of trade	Net barter terms of trade index (2015 = 100)	400	102.9	16.33	71.33	162.2
Industry employment	Percentage share in total employment	453	20.17	6.04	7.61	35.29
Lending interest rate	The rate at which commercial bank borrows from central banks	412	11.47	5.10	4.41	32.15
Money growth	Broad money growth minus GDP growth	423	9.61	8.22	-5.31	38.30

Notes: We do not show the descriptive statistics of 17 age cohorts for brevity.

Source: Authors' estimation using World Bank data and Penn World Table 10.01.

[7] We also use two monetary policy-related variables in the analysis: nominal rate and money growth following Juselius and Takáts (2021). The lending interest rate collected from WDI is used as a substitute for the nominal rate. Money growth is estimated, according to Juselius and Takáts (2021), as broad money growth adjusted for GDP growth.

[8] Denoted as $\hat{y}_{it} = y_{it} - y_{it}^{*}$, where y_{it} is the log real GDP, which is extracted from Penn World Table 10.01, and y_{it}^{*} is the potential GDP.

[9] With $\lambda = 10$, the standard value for yearly frequency.

The data on broad money growth and GDP growth are collected from WDI. Both affect inflation through the equation of exchange from QTM ($MV = PY$).[10] Broad money growth increases inflation, whereas GDP growth lowers inflation. To control the effects of international trade on the current account, which can influence inflation, we add terms of trade following Yoon et al. (2018). Terms of trade could impact inflation negatively because it will help reduce external debt and transfer income from abroad to the domestic economy, boosting domestic savings and long-term investments and reducing the price level (Singh, 2023). The data on terms of trade are obtained from WDI. Finally, we add industry employment following Isa (2021) as the study argued that not considering industry employment can lead to omitted variable bias in the model because the share of the population working in the industry also affects inflation.

3.2. Methodology

3.2.1. Modelling demographic Variable

An ideal model to capture the demographic effects of inflation would be the following;

$$Inflation_{it} = \beta_0 + \sum_{k=1}^{K} \beta_{1k}\, n_{kit} + \xi_{it}, \tag{1}$$

where, β_0 is the constant term; ξ_{it} is the error term. K refers to 17 that is number of total age cohorts.

However, due to the problem of multicollinearity, we cannot estimate each population share (n_{kit}) coefficients (β_{1k}) efficiently. To address this, Fair and Dominguez (1991) suggested an econometric method, recently applied by Juselius and Takáts (2021) and Kalafatcılar and Özmen (2021) allows all the age structures through population polynomial restriction. So, we restrict β_{1k} to lie on P^{th} degree of polynomial with the condition $P < K$ (P refers to highest polynomial degree):

$$\beta_{1k} = \sum_{p=0}^{P} \eta_p\, k^p = \eta_0 + \eta_1 k^1 + \cdots + \eta_p k^p, \tag{2}$$

where p refers to different population polynomial orders and η_p are the coefficients of the population polynomial. Substituting Equation (2) into Equation (1):

$$Inflation_{it} = \beta_0 + \eta_0 + \sum_{p=1}^{6} \eta_p \sum_{k=1}^{17} k^p\, n_{kit} + \xi_{it}. \tag{3}$$

The Equation (3) uses $\sum_{k=1}^{K} k^0\, n_{kit} = 1$. We use 6th-order polynomials in our

[10] MV=PY, where M is money supply; V is the velocity of money; P is the price level or inflation; Y is the output level or GDP.

model. Choosing the right polynomial degree can be tricky because of inter-household effects; different relationship patterns may emerge. However, we follow the approach of Macunovich (2012)[11] in choosing the degree of polynomials. Macunovich (2012) argues that choosing a lower-degree polynomial can be more problematic than a higher one because the former produces biased estimates compared to the latter, which produces unbiased but inefficient estimates. Thus, the present study starts at higher order polynomials and stops at the 6th degree of polynomials because lower than that produces insignificant estimates.

We put a second restriction, i.e., $\sum_{k=1}^{K}\beta_{1k} = 0$ because the sum of all population share is equal to one and perfectly collinear with a constant term. And we get:

$$\eta_0 = -\sum_{p=1}^{6}\eta_p \sum_{k=1}^{17}\left(\frac{k^p}{17}\right). \quad (4)$$

When we substitute Equation (4) into Equation (3), we obtain:

$$\mathit{Inflation}_{it} = \beta_0 + \sum_{p=1}^{6}\eta_p \sum_{k=1}^{17}\left(k^p n_{kit} - \frac{k^p}{17}\right) + \xi_{it}. \quad (5)$$

If we assign $\tilde{A}_{pit} = \sum_{k=1}^{17}\left(k^p n_{kit} - \frac{k^p}{17}\right)$, we get the final model as:

$$\mathit{Inflation}_{it} = \beta_0 + \sum_{p=1}^{6}\eta_p \tilde{A}_{pit} + \xi_{it}. \quad (6)$$

Once we estimate the six polynomial coefficients $(\eta_1, \cdots, \eta_4)$, the coefficients of all 17 age shares can be estimated with the help of Equation (2) (for details, refer to Juselius and Takáts, 2021).

3.2.1. Empirical Method

We employ the ordinary least squares model (OLS) as a starting point to estimate the relationship between demography and inflation. However, OLS does not consider individual heterogeneity, so we utilize the fixed effect (FE) model[12] to investigate the relationship along with two macroeconomic variables that are real interest rate (RIR) and output gap (OG):

$$\mathit{Inflation}_{it} = \beta_0 + \mu_i + \mu_t + \sum_{p=1}^{6}\eta_p \tilde{A}_{pit} + \beta_2 RIR_{it} + \beta_3 OG_{it} + \xi_{it}, \quad (7)$$

[11] Originally suggested by Judge et al. (1991).

[12] FE model is a standard model that is used by previous work (Gajewski, 2015; Juselius and Takáts, 2021; Broniatowska, 2019; Yoon et al., 2018) to study the relationship between inflation and demography.

where μ_i is the country-fixed effects and μ_t is the time-fixed effects. Following Juselius and Takáts (2021), we add time-fixed effects to control for global factors (including oil price shocks and significant financial crises).

Panel data model is susceptible to the problem of cross-sectional dependency (CD): we identify the problem by using Pesaran (2015, 2021) CD test.[13] After identifying the problem, we re-estimate the model with Driscoll-Kraay (DK) estimator (Hoechle, 2007)[14] for an efficient estimate.

4. RESULTS AND DISCUSSION

4.1. Empirical Analysis

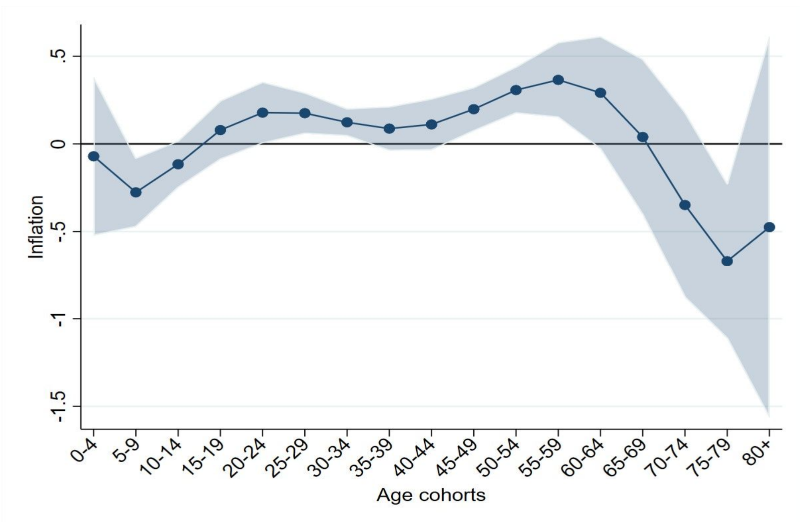
We provide the regression results in Table 2. The regression equation parameter is initially estimated using the OLS method. It can be observed that the relationship between demography and inflation is statistically significant (model 1, Table 2). When we add time-fixed effects in model 2 (Table 2) to guard against the concurrent global trends, the R-squared increases from 0.11% to 0.32%, but the higher population polynomial coefficient (A_6) becomes insignificant. However, individual effects must be controlled as we deal with panel data. Thus, in model 3 (Table 2), we add country-fixed effects, and it can be observed that R-squared increased further to 40%. Models 3 and 4 (Table 2) justify the use of the FE model. As a standard practice, we incorporate real interest rate and the output gap in our model (following Juselius and Takáts, 2015; Kalafatcılar and Özmen, 2021; Andrews et al., 2018) as control variables and find an expected sign for real interest rate consistent with previous studies but output gap turns out to be insignificant (model 4, Table 2). However, model 4 suffers from cross-sectional dependency, which can be confirmed by the rejection of the null hypothesis (weak cross-sectional dependency) of the Pesaran (2015, 2021) CD test (bottom row, Table 2). To address the CD issue, we employ the DK estimator in our preferred model (model 5, Table 2).

Using equation (2), we calculate age cohort effects for our preferred model (model 5) with ±2 standard deviations in Figure 4, which reveals that population shares of 15-69 in total population are inflationary, whereas population share of 0-14 and 70+ in total population are deflationary. However, the standard deviation at extreme ends, i.e., the very young group (0-4) and the very old group (80+), are much wider than the rest of the age cohorts, which implies the need for caution while interpreting the effects of these groups on inflation.

[13] For the CD test, we employ the Stata routine *xtcd2*, developed by (Ditzen, 2021)

[14] DK model helps to estimate the standard errors corrected for heteroskedasticity, autocorrelation, and cross-sectional dependency.

We find that the working-age population (15-64) and younger retirees (65-69) are inflationary, whereas the young group (0-14) and old group (70+) are deflationary. These findings align with the political economy model; we confirm the political economy model in the case of developing countries in Asia. We also find consistent results even when we divide the entire population into a broad category that is young (0-14), working-age (15-64), and old population (65+) groups, which means findings are independent of population polynomial technique we use.[15] Juselius and Takáts (2021) further argued that if interest misalignment is correct, nominal rate and money growth will be associated with demographics due to the misalignment, as central banks do not fully adjust changes in the real rate. Thus, the nominal rate, the sum of inflation and the real rate, might be associated with demographics through inflation. The money growth can also be associated with demography due to the misalignment as far as money supply is not inelastic. If interest rate[16] is too low (high) compared to the natural rate, so money demand will increase at a higher (lower) rate than what transactions or GDP growth would predict. Thus, this misalignment would result in excess money growth. Adding these two variables as dependent variables replacing inflation,[17] we confirm that the interest rate misalignment factor might not significantly explain the relationship between demography and inflation in our sample.



Notes: The figure is estimated based on model 5 (Table 2).

Figure 4. Age Cohorts' Effects on Inflation- Model 5 (Preferred Model)

[15] The results are available upon request.

[16] Also known as the price of money holding.

[17] The results are available upon request.

The political economy model explains why the working-age population is inflationary and old population groups are deflationary depending on the inflation preferences. However, the model does not explain why young age groups (0-14) are deflationary. We try to understand the deflationary effects of young groups from the intuition provided by Fedotenkov (2018) that as the fertility rate declines, the expenditure on newborns declines, which increases the real savings level and reduces the price level: this is true for our sample because countries experienced a rapid decline in total fertility rate (see Figure 1a).

Table 2. Regression Estimates-Demography and Inflation (Dependent Variable: Inflation)

Model	(1)	(2)	(3)	(4)	(5)
Estimation model	OLS	OLS	FE	FE	DK-FE
A1	-3.45***	-2.57**	-2.48**	-2.00*	-2.00*
	[0.95]	[1.10]	[1.00]	[1.12]	[1.01]
A2	1.66***	1.16**	1.28***	0.99*	0.99**
	[0.45]	[0.50]	[0.44]	[0.50]	[0.46]
A3	-0.35***	-0.23**	-0.28***	-0.21*	-0.21**
	[0.10]	[0.10]	[0.09]	[0.10]	[0.10]
A4	0.04***	0.02**	0.03***	0.02*	0.02**
	[0.01]	[0.01]	[0.01]	[0.01]	[0.01]
A5	-0.00***	-0.00*	-0.00***	-0.00*	-0.00**
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
A6	0.00***	0.00	0.00**	0.00*	0.00**
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Real interest rate				-0.10*	-0.10**
				[0.05]	[0.04]
Output gap				5.59	5.59
				[4.80]	[3.51]
Observations	424	424	424	355	355
R-squared	0.11	0.32			
R-squared (with fixed effects)	0.11	0.32	0.40	0.43	0.43
Time effects	No	Yes	Yes	Yes	Yes
Country fixed	No	No	Yes	Yes	Yes
Age structure F-test (p-value)	0.00	0.00	0.00	0.00	0.00
Pesaran CD tests (p-value)				0.002	

Notes: A_i corresponds to population polynomial ($\widetilde{A}_{pit}$) in Equation 7; DK-FE denotes Driscoll and Kraay fixed effects model; Robust standard errors in brackets in models 1-4; DK standard errors in brackets in model 5; Age structure F-test indicate the joint significance of 17 age cohorts; *** p<0.01, ** p<0.05, * p<0.1.

Source: Authors' estimation using World Bank data and Penn World Table 10.01.

4.2. Additional Controls

We add government debt, broad money growth, GDP growth, trade terms, and industry employment in our preferred model to check the consistency of our results and determine whether demography captures the effects of other variables.

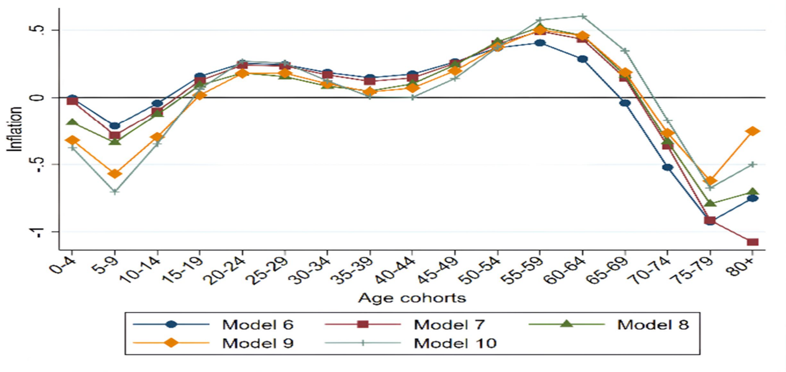
Table 3. Regression Estimates- Additional Controls Along with Demography and Inflation (Dependent Variable: Inflation)

Model	(6)	(7)	(8)	(9)	(10)
A1	-2.09**	-2.37**	-2.08*	-2.85*	-3.69**
	[0.98]	[0.94]	[1.08]	[1.61]	[1.83]
A2	1.04**	1.16**	1.08**	1.43*	1.85**
	[0.44]	[0.44]	[0.52]	[0.76]	[0.87]
A3	-0.22**	-0.24**	-0.24**	-0.30*	-0.39*
	[0.09]	[0.09]	[0.11]	[0.16]	[0.19]
A4	0.02**	0.03**	0.03**	0.03*	0.04*
	[0.01]	[0.01]	[0.01]	[0.02]	[0.02]
A5	-0.00**	-0.00**	-0.00*	-0.00*	-0.00*
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
A6	0.00**	0.00**	0.00*	0.00*	0.00*
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Real interest rate	-0.07	-0.07	-0.08	-0.11	-0.12*
	[0.05]	[0.05]	[0.05]	[0.07]	[0.07]
Output gap	6.38*	6.88*	8.09**	4.28**	5.39**
	[3.26]	[3.36]	[3.51]	[1.99]	[2.08]
Government debt	-0.03	-0.04	-0.04	0.02	0.01
	[0.04]	[0.04]	[0.04]	[0.05]	[0.06]
Broad money growth		-0.09***	-0.11***	-0.09***	-0.08***
		[0.03]	[0.02]	[0.02]	[0.02]
GDP growth			0.11	0.13	0.07
			[0.11]	[0.11]	[0.12]
Terms of trade				-0.03***	-0.04***
				[0.01]	[0.01]
Industry employment					0.24**
					[0.09]
Observations	289	273	260	233	226
R-squared (with fixed effects)	0.42	0.46	0.49	0.54	0.57
Time effects	Yes	Yes	Yes	Yes	Yes
Country fixed	Yes	Yes	Yes	Yes	Yes
Age structure F-test (p-value)	0.00	0.00	0.00	0.00	0.00

Notes: A_i corresponds to population polynomial ($\tilde{A}_{pit}$) in equation (7); We apply the first difference of government debt to make the series stationary. DK standard errors in brackets; Age structure F-test indicate the joint significance of 17 age cohorts; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Source: Authors' estimation using World Bank data and Penn World Table 10.01.

Table 3 presents the results for additional control variables. First, we include fiscal variables, i.e., government debt (model 6, Table 3), which do not affect the demographic coefficients. The government debt is expected to affect inflation positively (Juselius and Takáts, 2015), but we do not find the expected results, which suggests the potential omitted variable bias. Based on the QTM, we know that money supply growth (g_M) is positively[18] related to inflation, which means the higher the money supply growth ,the higher inflation. GDP growth (g_Y) is negatively related to inflation because a greater supply of goods and services decreases the price level. However, when we add broad money growth (model 7, Table 3), we find it has a negative relationship with inflation, which is neither consistent with QTM nor previous studies (Broniatowska, 2019 and Yoon et al., 2018). Nevertheless, a recent study by Buthelezi (2023) conducted in the case of South Africa outlined that broad money growth may have both positive and negative impacts on inflation depending on the mean inflation rate in the economy. When the mean inflation in the economy is within the range of inflation targeting (3% to 6%), broad money growth reduces inflation, indicating the effectiveness of the monetary policy. However, when inflation in the economy is not under an inflation targeting rate, the money supply increases inflation. The findings we get in model 7 (Table 3) may have to do with the fact that average inflation remains under the inflation target range, and as a result, we obtain a negative association between money supply growth and inflation. We find GDP growth insignificant (model 8, Table 3), contrary to Broniatowska (2019), which found a negative significant relationship with inflation.



Notes: The figure is estimated based on models 6-10 (Table 3).

Figure 5. The Effects of Age Cohorts on Inflation with Different Controls

[18] After converting the variables into growth rates, the QTM equation may be rewritten as, $g_M + g_V = g_P + g_Y$. If V and Y are exogenous constant, then $g_V = 0$ and $g_Y = 0$. Therefore $\uparrow g_M \rightarrow \uparrow g_P$ i.e., an increase broad money growth has a positive impact on inflation. Similarly rearranging the QTM equation, we get, $\uparrow g_Y \rightarrow \downarrow g_P$ i.e., the growth in output level negatively affects inflation.

We find that terms of trade reduce inflation (model 9, Table 3), which is consistent with Yoon et al. (2018). In the final model, we add industry employment in model 10 (Table 3) and find that it increases inflation, consistent with Isa (2021).

Despite including additional controls, demographic coefficients remain statistically significant in all the specifications (models 6-10, Table 3). Using equation (2), we estimate age cohort effects for models 6 to 10, as illustrated in Figure 5; we find similar patterns to those in the preferred model (Figure 4).

5. CONCLUSION

The study uncovers the relationship between demography and inflation in 19 developing Asian countries from 1995 to 2019. The study finds that the dependent population (young (0-14) and old (70+)) are deflationary, whereas the working-age populations are inflationary. The findings are robust to adding several macroeconomic controls. We find evidence in favor of the political economy model hypothesis that inflation is influenced by age group based on the inflation preference. However, we do not find evidence favoring the interest rate misalignment hypothesis.

As Bloom et al. (2010) and Nagarajan et al. (2017) rightly outlined, unlike developed countries, developing countries will experience demographic shifts, leading to population aging before the countries become rich. Therefore, it is crucial to focus on the macroeconomic impact of demography. Nevertheless, our findings suggest that the aging population negatively impacts inflation, contrary to the findings of Juselius and Takáts (2021). Based on our findings, the policy suggestions of Papapetrou and Tsalaporta (2020) become more important as the study emphasizes the role of central banks to follow more accommodative monetary policies to meet the inflation target. Our study finds that the inflationary pressure in our sample mainly derives from the changes in the working-age population and very young retirees (65-69). Therefore, it becomes imperative to follow inflation targeting stringently because Lau et al. (2022) show that inflation negatively impacts economic growth in developing countries of Asia. In addition, the central bank should also pay attention to mitigating the negative influence of the aging population on inflation.

The contribution of the study is that we have conducted an empirical investigation focusing on a panel of developing countries of Asia for the first time and found an intriguing outcome contrary to existing empirical findings on developed countries (Juselius and Takáts, 2021) and developing countries (Kalafatcılar and Özmen, 2021). The study can be used as a reference point for further investigation of the relationship between demography and inflation, focusing on different regions of Asia, for instance, Northern, Southern, Eastern, South-Eastern, and Western Asia.

Moreover, our findings also have some caveats; we outline a few: first, we analyze the demography from 1995 to 2019, which is slow-moving and may fall short of capturing the effects; thus, findings should be treated cautiously. Second, the implicit assumption that age cohorts had the same impact on inflation in 1995 and 2019 may be problematic. Third, the age cohorts at extreme ends, i.e., very young and very old, should be interpreted cautiously as a decline in fertility and an increase in life expectancy directly affects these cohorts. However, the main findings will be unaffected by the end cohorts as our focus is only on inner cohorts. Fourth, the data may be another concern in our study as we are dealing with developing countries; the missing value issue, which leads to reduced observations, may bias the estimates.

APPENDIX

Table A1: The List of Countries Used in the Study

No.	All Asian countries	19 selected countries in the study	No.	All Asian countries	19 selected countries in the study
1	Afghanistan		25	Maldives	Maldives
2	Armenia	Armenia	26	Mongolia	Mongolia
3	Azerbaijan		27	Myanmar	Myanmar
4	Bahrain	Bahrain	28	Nepal	Nepal
5	Bangladesh	Bangladesh	29	North Korea	
6	Bhutan	Bhutan	30	Oman	Oman
7	Brunei		31	Pakistan	
8	Cambodia		32	Philippines	Philippines
9	China	China	33	Qatar	
10	Cyprus		34	Saudi Arabia	
11	Georgia		35	Singapore	
12	India	India	36	South Korea	
13	Indonesia	Indonesia	37	Sri Lanka	Sri Lanka
14	Iran		38	State of Palestine	
15	Iraq		39	Syria	
16	Israel		40	Tajikistan	
17	Japan		41	Thailand	Thailand
18	Jordan	Jordan	42	Timor-Leste	
19	Kazakhstan		43	Turkey	
20	Kuwait	Kuwait	44	Turkmenistan	
21	Kyrgyzstan		45	UAE	
22	Laos		46	Uzbekistan	
23	Lebanon		47	Vietnam	Vietnam
24	Malaysia	Malaysia	48	Yemen	

Notes: According to the United Nations, there are 48 countries in Asia. UAE refers to United Arab Emirates.

Source: Authors' compilation.

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Received April 26, 2024, Accepted March 12, 2025.