Economics Bulletin

Volume 42, Issue 3

Population Aging and FDI inflows: A multi-country cointegration analysis

Rajarshi Mitra
Tokyo International University

Md. Thasinul Abedin
University of Chittagong

Kanon Kumar Sen
Jahangirnagar University

Abstract

The neoclassical theory posits an inverse relationship between population ageing and FDI inflows. We investigate the short-run and long-run relationships between population ageing and net FDI inflows (% of GDP) for 20 OECD countries, controlling for real national income, real exchange rate, trade openness and domestic investment. The autoregressive distributed lag (ARDL) bounds testing approach to cointegration is applied. In contrast to the neoclassical proposition, the long-run effects of population ageing on net FDI inflows (% of GDP) are found to be country-specific. The effects are significantly negative for Australia, Austria, Costa Rica, Denmark, Finland, Spain and Sweden; significantly positive for Colombia, Germany, Greece, Italy, Japan, Norway and Portugal, and insignificant for Belgium, Chile, France, Mexico, the UK and the USA.

Citation: Rajarshi Mitra and Md. Thasinul Abedin and Kanon Kumar Sen, (2022) "Population Aging and FDI inflows: A multi-country cointegration analysis", *Economics Bulletin*, Volume 42, Issue 3, pages 1631-1644
Contact: Rajarshi Mitra - rmitra@tiu.ac.jp, Md. Thasinul Abedin - abedin@cu.ac.bd, Kanon Kumar Sen - kanon@juniv.edu.
Submitted: July 05, 2022. **Published:** September 30, 2022.

Economics Bulletin

Submission Number: EB-22-00510

Population Ageing and FDI Inflows: A Multi-Country Cointegration Analysis

Rajarshi Mitra
Tokyo International University

Md. thasinul Abedin
University of Chittagong

Kanon Kumar Sen
Jahangirnagar University

Abstract

The neoclassical theory posits an inverse relationship between population ageing and FDI inflows. We investigate the short-run and long-run relationships between population ageing and net FDI inflows (% of GDP) for 20 OECD countries, controlling for real national income, real exchange rate, trade openness and domestic investment. The autoregressive distributed lag (ARDL) bounds testing approach to cointegration is applied. In contrast to the neoclassical proposition, the long-run effects of population ageing on net FDI inflows (% of GDP) are found to be country-specific. The effects are significantly negative for Australia, Austria, Costa Rica, Denmark, Finland, Spain and Sweden; significantly positive for Colombia, Germany, Greece, Italy, Japan, Norway and Portugal, and insignificant for Belgium, Chile, France, Mexico, the UK and the USA.

Submitted: July 05, 2022.

1. Introduction

Some industrialized countries, such as Japan and the Republic of Korea, amongst others, are faced with a declining population today. In OECD countries, the number of individuals aged 65 years and above as a percentage of total population is steadily increasing. The neoclassical model predicts that, as the working age population in the developed countries shrinks, the capital-labor ratio in those countries will rise. Due to diminishing returns to factor inputs, the returns to capital relative to labor will fall; consequently, capital will flow from the developed to the developing countries, and net FDI inflows into the developed countries will decrease. In other words, with few restrictions on cross-border capital flows, capital will flow from the industrialized countries with relatively more aged societies and high dependency ratios to developing countries with relatively younger population and low dependency ratios. Therefore, according to the predictions of the neoclassical theory, an increase in the proportion of elderly individuals in total population will most likely be associated with a decrease in FDI inflows. An increase in population ageing in a country is expected to reduce FDI inflows in that country.

The importance of foreign capital inflows for sustainable economic growth is well documented in the macroeconomic literature. Because of the neoclassical proposition, the inverse relationship between population ageing and FDI inflows is important from a policy standpoint. Population ageing is a policy concern for the national governments of OECD countries because of continuously rising social expenditures, and steadily declining tax revenues and foreign capital inflows. While academicians and policy makers have investigated how an ageing population may affect national saving and investment rates, per-capita GDP growth and national labor force, population ageing as a potential determinant of FDI inflows has received scant scholarly attention.

Figure 1 shows that, from 1980-2019, the proportion of elderly in total population of all 37 OECD member countries increased from 10.62% to 17.08%.

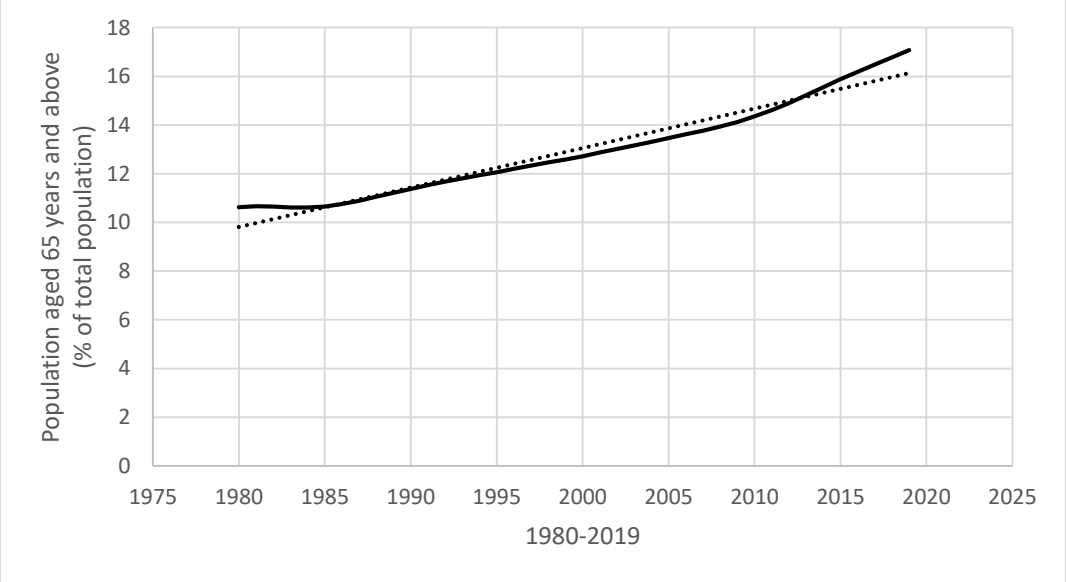

Figure 1. Proportion of Elderly in Total Population

In line with the predictions of economic theory, we would expect foreign investment inflows (% of GDP) in all OECD member countries to decrease. However, Figure 2 shows that, net FDI inflows (% of GDP) actually increased from 0.57% to 1.68%.

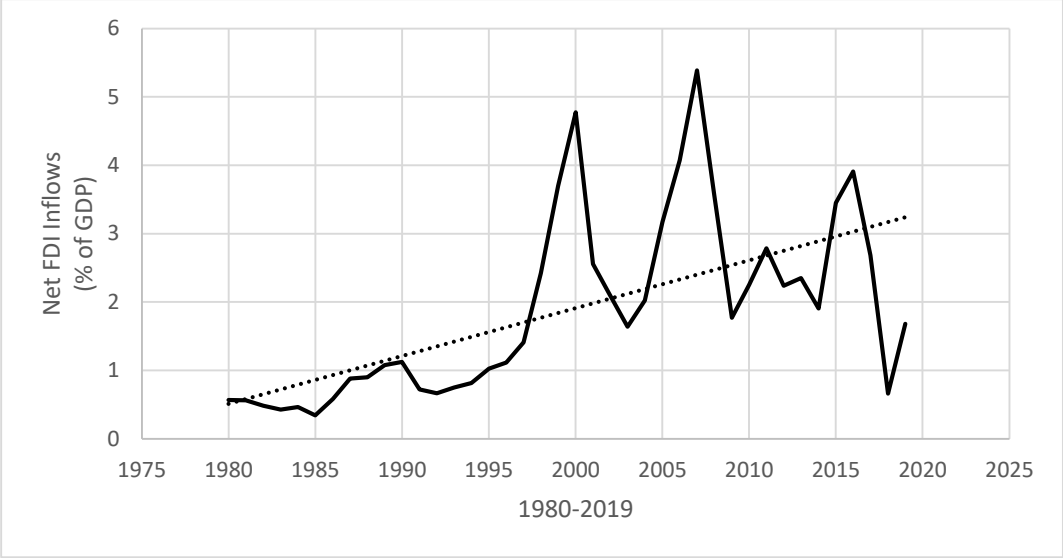

Figure 2. Net FDI Inflows in Proportion to GDP

The positive trend in the net FDI inflows (% of GDP) is a contradiction to the predictions of the neoclassical model. Any interpretation of a potential positive association between population ageing and net FDI inflows (% of GDP) for all OECD member countries must be treated with caution due to potential aggregation bias. Secondly, demographic changes occur slowly over time. From a policy standpoint, a country-case analysis is more appropriate than a cross-sectional or a panel study. Very little scholarly attention has been given to examining the existence of a cointegrating relationship between population ageing and net FDI inflows for the individual OECD economies, especially with structural breaks in time series data. This paper fills the gap in the extant literature by examining the short-run and long-run effects of an increase in the number of individuals aged 65 years and above (% of total population) on net FDI inflows (% of GDP) with structural breaks, individually, for 20 OECD countries, while controlling for real national income, real effective exchange rate, trade openness, and domestic investment.

2. Theoretical Framework

As Zebregs (1998) noted, "FDI comes closest to the definition of foreign capital in the standard neoclassical model" that is developed by MacDougall (1960), amongst others. How does the standard neoclassical model explain FDI flows across countries? To answer that question, let us consider a simple constant-returns-to-scale Cobb-Douglas production function of the form

$$\mathrm{Y} = \mathrm{A}K^{\alpha}L^{1-\alpha} \tag{1}$$

In equation (1), Y is output, A is total factor productivity, K is capital stock, and L is labor. Dividing both sides of equation (1) by L yields

$$y = f(k) = Ak^{\alpha} \quad (2)$$

In equation (2), y is real GDP per worker, and k is capital stock per worker employed (K/L). The parameter α shows capital`s share in total output. A large α indicates that production is more intensive in capital relative to labor. The marginal product of capital per worker employed is

$$\frac{dy}{dk} = f`(k) = A\alpha k^{\alpha-1} = \frac{A\alpha}{k^{1-\alpha}} \quad (3)$$

Equation (3) implies that, due to diminishing returns to factor inputs, a rise in the K/L ratio would be associated with a fall in the marginal product of capital per worker, and vice-versa; therefore, a country with a low marginal product of capital per worker would experience an outflow of capital to a country with a relatively high marginal product of capital. Eventually, marginal products of capital per worker in the two countries would become equal (see Barro et al., 1995). If the OECD countries are experiencing population ageing, then one would expect K/L ratio in the OECD countries to rise and marginal product of capital per worker to fall. According to the neoclassical hypothesis, capital would then flow from the OECD countries with high K/L ratios to the developing countries with low K/L ratios. The neoclassical model, thus, hypothesizes a negative association between population ageing and net FDI inflows (% of GDP) for the OCED economies.

3. Literature Review

Despite the theoretical underpinning, academic literature has neglected an empirical investigation of the direct effects of population ageing on FDI inflows for individual OECD economies. Additionally, across empirical studies that have examined the relation between population ageing and FDI inflows, the results are mixed. For instance, with population ageing, Knickerbocker (1973) reported an increase in FDI flows to the relatively "younger" economies in the presence of oligopolistic competition. While Narciso (2010) also observed a negative effect of population ageing on foreign capital inflows in OECD countries, Tomohara (2017) argued that, if "migrant networks" increase business opportunities via FDI, then population ageing may be associated with an increase in FDI inflows. Similar to Tomohara (2017), in a country-case study based on cointegration analysis, Mitra and Abedin (2020) reported a significantly positive long-run effect of population ageing on net FDI inflows in Japan. In panel cointegration analysis based on the ARDL approach, Mitra and Abedin (2021) reported a significantly positive long-run effect of population ageing on net FDI inflows for 26 OECD countries. Mitra and Abedin (2022) reported a positive correlation between working age population and net FDI inflows for a panel of 22 OECD countries; thus, a shrinking labor force, say, due to population ageing, would be associated with a decrease in net FDI inflows. Mitra and Guseva (2021), based on Bayesian panel VAR estimates, reported lack of a significant relation between population ageing and FDI inflows.

Recent studies by Ikeda and Saito (2014), Carvalho et al. (2016), Arslanalp et al. (2019), Emerson and Knabb (2019), and Papetti (2021) have shown that population ageing would lead to a decline in the real interest rate. This would have implications for the net FDI inflows in countries that are faced with an ageing population. That is because when the capital market is competitive, then in equilibrium, marginal product of capital would be equal to the real interest rate; therefore, a fall in the marginal product of capital, due to a rising capital-labor ratio and diminishing returns, would

imply a fall in the real interest rate; consequently, capital would flow from the OECD countries to countries with high marginal product of capital and high real interest rate.

Although the empirical findings on the relation between population ageing and the real interest rate is consistent with the neoclassical proposition, it is important to examine the direct relation between population ageing and FDI inflows for individual OECD economies. This paper tests the hypothesis that population ageing would be associated with a decrease in net FDI inflows (% of GDP) in the 20 OECD countries. The cointegration technique with structural breaks allows us to not only distinguish the short-run effects of population ageing on the net FDI inflows (% of GDP) from its long-run effects, but also identify the significant breaks in time series data.

4. Data and the Model

4.1 Data: Annual data from the World Bank on Australia, Austria, Belgium, Chile, Columbia, Costa Rica, Denmark, Finland, France, Germany, Greece, Italy, Japan, Mexico, Norway, Portugal, Spain, Sweden, the UK and the USA are obtained. The study period is 1980-2019. The dependent variable in our model is net FDI inflows (% of GDP). It is the difference between new investment inflows and disinvestment in the reporting economy from foreign investors (% of GDP). Population ageing is measured by the number of individuals aged 65 years and above (% of total population). The control variables are: (a) real GDP as a measure of national income, (b) trade openness measured by the sum of exports and imports (% of GDP), (c) the real effective exchange rate index, and (d) domestic investment (% of GDP). An increase (decrease) in the exchange rate index would imply an appreciation (depreciation) of the domestic currency.

4.2 The Model: The effect of population ageing on net FDI inflows (% of GDP) for each country separately at time t is examined by estimating a model of the form

$$FDI_t = \alpha_0 + \alpha_1 OLD_t + \alpha_2 GDP_t + \alpha_3 OPN_t + \alpha_4 RER_t + \alpha_5 INV_t + \varepsilon_t \quad (4)$$

FDI is the foreign direct investment, net inflows (% of GDP); OLD is the number of individuals aged 65 years and above (% of total population); GDP in real terms as a measure of national income; OPN is the trade-to-GDP ratio; RER is the real effective exchange rate index; INV is the domestic investment (% of GDP); ε_t is random error with mean zero; *t* represents the time suffix.

5. Main Results

5.1 Unit Root Tests: The Zivot and Andrews (1992) unit root tests with a single structural break are first performed. The results indicate a mixed order of integration for the FDI variable, and for that reason, the auto-regressive distributed lag (ARDL) approach to cointegration analysis is applied. The ARDL bounds testing approach does not require pretests for a unit root. The results of the unit root tests are not reported because of space constraints.

5.2 Multiple Break Tests: The multiple break test proposed by Bai and Perron (1998, 2003) is performed for each of the 20 OECD countries. A maximum of five breaks is allowed, and the significant break year is selected using the Schwarz criterion and the modified Schwarz (LWZ) criterion. The results are reported in Table 1.

Table 1. Multiple Break Test

	Schwarz Criterion	LWZ	Break Year(s)
Australia	1	1	2006*
Austria	2	0	2004, 2010*
Belgium	2	2	1999, 2012*
Chile	1	1	1996*
Colombia	2	2	1996, 2005*
Costa Rica	3	3	1996, 2004*, 2010
Denmark	2	0	1997, 2003*
Finland	2	1	1998*, 2009
France	3	3	1989, 1999, 2009*
Germany	2	1	1998, 1999, 2004*
Greece	3	1	1997, 2003, 2013*
Italy	2	2	1996, 2005*
Japan	2	1	1999*, 2014*
Mexico	1	1	1994*
Norway	2	2	1996, 2013*
Portugal	1	1	1998*
Spain	2	2	1999*, 2009*
Sweden	2	2	1998, 2009*
UK.	2	0	1998*, 2009
USA	1	1	1997*

Note: * denotes the significant break year(s).

5.3 Cointegration Test: The equation of interest is modelled as a conditional ARDL framework as specified below

$$\Delta FDI_t = \alpha_0 + \alpha_1 DUM + \sum_{h=1}^{p} \alpha_{2h}\, \Delta FDI_{t-h} + \sum_{j=0}^{q} \alpha_{3j}\, \Delta OLD_{t-j} + \sum_{k=0}^{r} \alpha_{4k}\, \Delta GDP_{t-k} + \sum_{l=0}^{s} \alpha_{5l}\, \Delta OPN_{t-l} + \sum_{m=0}^{v} \alpha_{6m}\, \Delta RER_{t-m} + \sum_{n=0}^{w} \alpha_{7n}\, \Delta INV_{t-n} + \beta_1 FDI_{t-1} + \beta_2 OLD_{t-1} + \beta_3 GDP_{t-1} + \beta_4 OPN_{t-1} + \beta_5 RER_{t-1} + \beta_6 INV_{t-1} + \omega_t \quad (5)$$

We perform the F-test for cointegration for each country with the corresponding significant break year indicated in Table 1. If the computed F-statistic is greater than the upper bound of the critical values, then the null hypothesis of no cointegration is rejected. If the computed F-statistic is less than the lower bound of the critical values, then there is no cointegration. If the computed F-statistic falls between the upper and the lower bounds, then the decision on cointegration will be inconclusive at the chosen level of significance. The results of the ARDL cointegration tests are reported in Table 2.

Table 2. Cointegration Tests

	Significant Break Year	F-statistic
Australia	2006	23.98***
Austria	2010	22.31***
Belgium	2012	6.95***
Chile	1996	11.92***
Colombia	2005	7.65***
Costa Rica	2004	9.21***
Denmark	2003	4.60***
Finland	1998	32.60***
France	2009	4.78***
Germany	2004	9.59***
Greece	2013	106.15***
Italy	2005	9.59***
Japan	1999	16.40***
Japan	2014	10.89***
Mexico	1994	6.78***
Norway	2013	15.41***
Portugal	1998	99.29***
Spain	1999	19.16***
Spain	2009	129.69***
Sweden	2009	11.20***
UK	1998	11.58***
USA	1997	4.96***

Note: *** denotes significant at 1% significance level. The lower and the upper bounds corresponding to 1% significance level for Italy and Columbia are (3.27, 4.39) and (3.15, 4.43), respectively. For all other countries, the lower and the upper bounds corresponding to 1% significance level are (2.88, 3.99).

The results in Table 2 indicate whether or not a cointegrating relationship exists when FDI is the dependent variable. The computed values of the F-statistic for Australia, Austria, Belgium, Chile, Costa Rica, Denmark, Finland, France, Germany, Greece, Japan, Mexico, Norway, Portugal, Spain, Sweden, the UK and the USA are greater than the upper bound of the critical values (3.99) at the 1% significance level. For Colombia, the computed value of the F-statistic is greater than the upper bound of the critical values (4.43) at the 1% significance level. For Italy, the computed value of the F-statistic is greater than the upper bound of the critical values (4.39) also at the 1% significance level. The results, therefore, provide evidence of a long-run relationship in the model with FDI as the dependent variable for each of the 20 OECD countries.

5.4 Short-Run Effects: The short-run model has the following ARDL (p, q, r, s, v, w, z) specification

$$\Delta FDI_t = \alpha_0 + \sum_{g=1}^{p} \alpha_{1g}\, \Delta FDI_{t-g} + \sum_{h=0}^{q} \alpha_{2h}\, \Delta OLD_{t-h} + \sum_{j=0}^{r} \alpha_{3j}\, \Delta GDP_{t-j} + \sum_{k=0}^{s} \alpha_{4k}\, \Delta OPN_{t-k}$$

$$+ \sum_{l=0}^{v} \alpha_{5l}\, \Delta RER_{t-l} + \sum_{m=0}^{w} \alpha_{6m}\, \Delta INV_{t-m} + \sum_{n=0}^{z} \alpha_{7n} \Delta DUM_{t-n} + \lambda ECM_{t-1} + \mu_t \qquad (6)$$

In equation (6), λ denotes the speed of adjustment toward long-run equilibrium, if there is any shock to net FDI inflows (% of GDP) due to changes in the number of individuals aged 65 and above (% of total population) and the covariates. The short-run results are reported in Table 3.

Table 3. Short-Run Coefficients

	ΔOLD	ΔGDP	ΔOPN	ΔRER	ΔINV	ΔDUM	ECM_{t-1}
Australia	7.62	9.23e-11***	-0.29**	-0.16***	-0.79***	7.15***	-0.84***
	(0.25)	(0.00)	(0.02)	(0.00)	(0.00)	(0.00)	(0.00)
Austria	0.60	-8.13e-12	0.64***	1.65***	-9.03***	70.84***	-0.78***
	(0.96)	(0.95)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Belgium	74.66***	-4.77e-11	-0.61***	-1.21***	15.41***	-1.51***	-0.85***
	(0.00)	(0.88)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Chile	-3.45	2.64e-10***	0.39***	-0.28***	0.05	-0.29***	-0.51***
	(0.70)	(0.00)	(0.00)	(0.00)	(0.62)	(0.00)	(0.00)
Colombia	-40.45**	-1.20e-11***	0.26**	0.04***	0.17	-0.42***	-0.18***
	(0.02)	(0.00)	(0.02)	(0.00)	(0.15)	(0.00)	(0.00)
Costa Rica	33.16***	1.17e-10	0.14***	-0.05***	-0.08***	2.29***	-0.47***
	(0.00)	(0.31)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Denmark	-3.74	4.41e-10***	-0.10	-0.37	-2.14***	-8.75***	-0.09***
	(0.78)	(0.00)	(0.60)	(0.24)	(0.00)	(0.00)	(0.00)
Finland	-33.25***	3.78e-10***	-0.35***	-0.19***	-1.16***	-1.20***	-0.78***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
France	-0.55	1.33e-11***	-0.03	-0.09**	-0.12	-2.03***	-0.17***
	(0.24)	(0.00)	(0.59)	(0.03)	(0.52)	(0.00)	(0.00)
Germany	38.63***	-5.34e-11*	1.06*	0.15***	1.14***	-27.99***	-0.59***
	(0.00)	(0.09)	(0.08)	(0.00)	(0.00)	(0.00)	(0.00)
Greece	0.88***	1.21e-10***	0.10***	0.01***	-0.26***	-1.68***	-0.24***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Italy	-77.19***	-1.27e-10***	0.33*	0.02	0.09	-1.07***	-0.38***
	(0.00)	(0.00)	(0.09)	(0.11)	(0.22)	(0.00)	(0.00)
Japan	-5.97***	4.01e-12***	-0.11***	0.05***	0.17***	0.14***	-0.53***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Japan	-5.57***	4.94e-12***	-0.03***	0.01***	0.02***	-0.57***	-0.97***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Mexico	19.65***	5.80e-12***	0.07***	0.02***	-0.37***	1.44***	-0.74***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Norway	6.91***	6.63e-11***	0.27***	0.11	0.37***	-5.03***	-0.51***
	(0.00)	(0.00)	(0.00)	(0.28)	(0.00)	(0.00)	(0.00)
Portugal	-345.8***	1.53e-09***	-1.91**	-2.93**	-20.60***	69.70***	-0.72***
	(0.00)	(0.00)	(0.02)	(0.02)	(0.00)	(0.00)	(0.00)
Spain	-11.42***	1.89e-12	0.25***	-0.04	0.35***	2.32***	-0.41***
	(0.00)	(0.74)	(0.00)	(0.12)	(0.00)	(0.00)	(0.00)
Spain	-9.71***	1.86e-12***	0.11***	-0.19***	1.94***	7.62***	-0.93***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Sweden	-141.4***	-3.73e-10***	-0.31***	-0.002	3.78***	52.40***	-0.04***
	(0.00)	(0.00)	(0.00)	(0.95)	(0.00)	(0.00)	(0.00)
UK	39.99***	4.86e-11***	0.26***	-0.14***	-0.81***	-4.83***	-0.50***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
USA	-0.69	1.96e-12***	0.16***	-0.005	-0.27***	1.17***	-0.59***
	(0.14)	(0.07)	(0.00)	(0.68)	(0.00)	(0.00)	(0.00)

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

The short-run effects of population ageing on net FDI inflows (% of GDP) are significantly positive for Belgium, Costa Rica, Germany, Greece, Mexico, Norway and the UK; significantly negative for Colombia, Finland, Italy, Japan, Portugal, Spain and Sweden. The effects are insignificant for Australia, Austria, Chile, Denmark, France and the USA. The short-run effects of national income, trade openness, exchange rate, domestic investment and the break year dummy are also mixed; thus the short-run effects are, overall, mixed and country-specific. The adjustment coefficients have the expected negative sign and are statistically significant at the 1% significance level for all 20 countries, indicating convergence toward long-run equilibrium.

5.5 Long-Run Effects: The long-run model has the ARDL (p, q, r, s, v, w, z) specification

$$FDI_t = \alpha_0 + \sum_{h=0}^{p} \alpha_{1h}\, FDI_{t-h} + \sum_{j=0}^{q} \alpha_{2j}\, OLD_{t-j} + \sum_{k=0}^{r} \alpha_{3k}\, GDP_{t-k} + \sum_{l=0}^{s} \alpha_{4l}\, OPN_{t-l}$$

$$+ \sum_{m=0}^{v} \alpha_{5m}\, RER_{t-m} + \sum_{n=0}^{w} \alpha_{5n}\, INV_{t-n} + \sum_{u=0}^{z} \alpha_{6u}\, DUM_{t-u} + \varphi_t \qquad (7)$$

The long-run coefficients of net FDI inflows (% of GDP) with respect to the number of individuals aged 65 and above (% of total population) and the covariates are reported in Table 4.

Table 4. Long-Run Coefficients

	OLD	GDP	OPN	RER	INV	DUM
Australia	-7.16***	3.37e-11***	-0.14	-0.17***	-0.82***	3.47***
	(0.00)	(0.00)	(0.12)	(0.00)	(0.00)	(0.00)
Austria	-33.93***	1.23e-10	1.10***	3.09***	-11.03***	58.21***
	(0.00)	(0.17)	(0.00)	(0.00)	(0.00)	(0.00)
Belgium	2.77	2.58e-10	-2.01***	-3.51***	14.01***	-19.81***
	(0.72)	(0.21)	(0.00)	(0.00)	(0.00)	(0.00)
Chile	3.82	-4.75e-11	0.44***	0.001	0.97***	-6.39***
	(0.11)	(0.37)	(0.00)	(0.95)	(0.00)	(0.00)
Colombia	1.12*	4.97e-11**	0.16**	0.04***	0.06	-2.14***
	(0.08)	(0.03)	(0.01)	(0.00)	(0.26)	(0.00)
Costa Rica	-3.86**	-9.23e-11	0.25**	0.09	-0.32	5.27***
	(0.02)	(0.82)	(0.01)	(0.13)	(0.20)	(0.00)
Denmark	-1.21*	8.34e-11**	0.02	-0.27	0.14	-6.13***
	(0.06)	(0.03)	(0.91)	(0.27)	(0.74)	(0.00)
Finland	-1.75***	1.55e-10***	-0.01	-0.12***	0.02	-6.38***
	(0.00)	(0.00)	(0.77)	(0.00)	(0.84)	(0.00)
France	-0.09	3.13e-12**	-0.06	-0.12*	-0.04	-2.35***
	(0.68)	(0.02)	(0.49)	(0.08)	(0.66)	(0.00)
Germany	1.08***	-2.77e-12***	0.11***	-0.04**	0.35***	-5.78***
	(0.00)	(0.00)	(0.00)	(0.02)	(0.00)	(0.00)
Greece	3.33***	-9.00e-11***	-0.34***	-0.01	0.69***	-0.20***
	(0.00)	(0.00)	(0.00)	(0.49)	(0.00)	(0.00)
Italy	4.01***	3.72e-11	0.15***	0.03***	0.12	-2.91***
	(0.00)	(0.56)	(0.00)	(0.03)	(0.29)	(0.00)
Japan	0.02***	7.73e-14**	-0.03***	-0.01***	0.04***	0.16***
	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)
Japan	0.08***	4.16e-14***	-0.01***	-0.01***	0.02***	-0.27***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Mexico	-1.97***	8.86e-12***	-0.02	0.002	-0.13***	1.24***
	(0.00)	(0.00)	(0.40)	(0.72)	(0.00)	(0.00)
Norway	1.14***	2.73e-11***	0.20***	0.01	0.33***	-5.99***
	(0.00)	(0.00)	(0.00)	(0.84)	(0.00)	(0.00)
Portugal	3.01***	-5.39e-10***	0.19***	1.10***	2.74***	17.88***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Spain	-1.58***	-6.20e-12	0.32***	0.01	0.54***	6.80***
	(0.00)	(0.24)	(0.00)	(0.86)	(0.00)	(0.00)
Spain	-1.13***	-8.46e-12*	0.17***	0.05**	0.52***	15.97***
	(0.00)	(0.06)	(0.00)	(0.01)	(0.00)	(0.00)
Sweden	-1.83***	-7.46e-11***	1.02***	0.21***	1.05***	11.61***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
UK	1.67	1.36e-11***	-0.56***	0.31***	-0.41***	-11.44***
	(0.27)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
USA	0.40	-4.16e-12*	0.20**	-0.02	0.25**	1.70***
	(0.16)	(0.07)	(0.02)	(0.23)	(0.02)	(0.00)

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

For Australia, Austria, Costa Rica, Denmark, Finland, Mexico, Spain and Sweden, an increase in the number of individuals aged 65 and above (% of total population) is found to have a significantly negative long-run effect on net FDI inflows (% of GDP); thus, population ageing is expected to result in a decrease in FDI inflows (% of GDP) in those eight OECD countries. This is consistent with the predictions of the neoclassical theory. For Belgium, Chile, France, UK and USA, the long-run relationships are insignificant. For Colombia, Germany, Greece, Italy, Japan, Norway and Portugal, the long-run relationships are significantly positive. Therefore, the long-run effects of population ageing on net FDI inflows (% of GDP) are mixed, which is a contradiction to the predictions of the neoclassical theory. The long-run effects of increases in real national income, trade openness, real effective exchange rate, domestic investment, and the break year dummy are also mixed and country-specific.

For Finland, Spain and Sweden, the short-run and long-run effects of population ageing on the net FDI inflows (% of GDP) are both significantly negative. For Germany, Greece and Norway, the short-run and long-run effects are both significantly positive. For Colombia, Italy, Japan and Portugal, a significantly negative short-run effect is offset by a significantly positive long-run effect, thereby giving rise to a J-curve phenomenon. The opposite effect is observed in Mexico - a significantly positive short-run effect is offset by a significantly negative long-run effect.

The significantly positive long-run coefficients of population ageing are a contradiction to what the neoclassical economic theory postulates, but consistent with the stylized facts discussed in Figure 1 and Figure 2. There could be several reasons why the association between population ageing and net FDI inflows (% of GDP) is significantly positive for some OECD countries. As discussed in Mitra and Abedin (2000), when old people dissave, there could be a shortage of domestic capital, which might strengthen the need for foreign investment. A second reason could be that, as the proportion of elderly in total population increases, the size of the labor force shrinks; consequently, the price of labor increases. Capital becomes relatively cheaper, and the demand for foreign capital, and net FDI inflows (% of GDP), increases. There have been efforts to increase the retirement age. An increase in the retirement age might mitigate the negative effects of population ageing on the net FDI inflows (% of GDP). An increase in the retirement age combined with efforts to equip the elderly workers with superior technology would increase productivity. An increase in productivity would attract foreign capital; in other words, the older economies may attract foreign capital because those economies are technologically more advanced. Tomohara (2017) argues that Japan, in order to counteract the negative effects of population ageing, have implemented “inward FDI-promotion and immigration enhancement” policies in order to attract foreign capital and makeup for shortages in domestic capital and labor. Trade barriers in some industrial sectors have either been lowered or removed. Head and Ries (2005) and Hibbard et al. (2009) argue that the new legislation in Japan may facilitate “the acquisition of Japanese firms by foreign investors”. Taking initiatives to make information about investment opportunities available to the foreign investors, and the introduction of new corporate governance rules would make the domestic companies more attractive to the foreign companies that engage in FDI. The immigration rules in some OECD countries are being revised with a view to attract more foreign labor and capital; for instance, the introduction of a fast track permanent residence program in Japan. Large-scale investments in health and education may also attract foreign capital and counteract the negative effects of population ageing. From a policy perspective, the factors

discussed above could be considered plausible to counteract the negative and even the insignificant long-run effects of population ageing on the net FDI inflows (% of GDP).

5.6 Diagnostic Tests: The chi-square statistics for the diagnostic tests are reported in Table 5. The model fails to reject the null hypothesis of (a) no autocorrelation at lag order, (b) no conditional heteroskedasticity, (c) normally distributed errors, and (d) correct model specification. The CUSUM and CUSUMSQ test results indicate that the model is stable.

Table 5. Model Diagnostics

	$\chi^2_{Autocorrelation}$	χ^2_{ARCH}	$\chi^2_{Normality}$	$\chi^2_{Misspecification}$	$CUSUM$	$CUSUMSQ$
Australia	1.27 (0.33)	0.17 (0.68)	0.07 (0.96)	1.72 (0.21)	S	S
Austria	1.16 (0.32)	0.81 (0.37)	0.11 (0.94)	5.41 (0.11)	S	S
Belgium	1.82 (0.19)	0.32 (0.57)	12.72*** (0.00)	1.95 (0.16)	S	S
Chile	1.83 (0.25)	0.03 (0.86)	0.26 (0.88)	2.27 (0.18)	S	S
Colombia	2.46 (0.12)	0.04 (0.85)	0.20 (0.91)	1.96 (0.18)	S	S
Costa Rica	2.36 (0.16)	1.90 (0.17)	1.28 (0.53)	2.26 (0.17)	S	S
Denmark	1.55 (0.24)	0.02 (0.88)	78.23*** (0.00)	3.31 (0.23)	S	S
Finland	1.83 (0.21)	0.04 (0.84)	1.02 (0.60)	0.90 (0.34)	S	S
France	5.35 (0.16)	1.64 (0.19)	0.01 (0.99)	0.07 (0.79)	S	S
Germany	1.61 (0.24)	0.06 (0.80)	4.01 (0.13)	2.15 (0.14)	S	S
Greece	9.51 (0.20)	7.70 (0.18)	4.30 (0.11)	0.27 (0.61)	S	S
Italy	28.29 (0.13)	1.55 (0.21)	0.57 (0.75)	4.07 (0.20)	S	S
Japan	9.97 (0.22)	0.02 (0.88)	1.02 (0.60)	0.03 (0.85)	S	S
Japan	1.37 (0.31)	0.15 (0.70)	3.67 (0.16)	0.32 (0.57)	S	S
Mexico	4.42 (0.11)	1.33 (0.25)	0.09 (0.96)	1.86 (0.17)	S	S
Norway	3.67 (0.16)	0.0005 (0.98)	0.60 (0.74)	1.72 (0.19)	S	S
Portugal	1.73 (0.20)	0.04 (0.84)	1.44 (0.49)	2.52 (0.11)	S	S
Spain	5.45 (0.30)	6.69 (0.15)	0.36 (0.83)	1.40 (0.24)	S	S
Spain	0.78 (0.54)	2.47 (0.11)	0.29 (0.87)	4.14 (0.29)	S	S
Sweden	4.13 (0.14)	2.32 (0.13)	0.90 (0.64)	0.73 (0.45)	S	S
UK	1.77 (0.18)	4.55 (0.11)	3.29 (0.19)	0.001 (0.99)	S	S
USA	0.08 (0.78)	1.04 (0.31)	0.12 (0.94)	1.74 (0.19)	S	S

Note: ***denotes significant at 1% significance level. *S* denotes the model is stable.

6. Conclusion

We test the hypothesis that is derived from the neoclassical model that population ageing significantly reduces net FDI inflows (% of GDP) in the OECD countries. The results of the unit

root tests with structural breaks indicate a mixed order of integration for the FDI variable, which is the dependent variable in our model. The mixed results motivate us to apply the ARDL bounds testing approach to cointegration. The bounds testing approach proposed by Pesaran and Pesaran (1997), Pesaran and Shin (1999) and Pesaran et al. (2001) to investigate the existence of a long-run relationship between the variables can be applied within an ARDL framework regardless of whether the variables are I(0), I(1) or fractionally integrated.

In contrast to the predictions of the neoclassical theory, the short-run and long-run effects are mixed; therefore, policy implications would be country-specific. No single policy instrument to counteract the negative effects of population ageing can be commonly suggested for all 20 OECD countries. In the case of Colombia, Italy, Japan and Portugal, the central tenet of the neoclassical theory appears to have just a short-run validity. The immediate (short-run) effect of population ageing on net FDI inflows (% of GDP) in those four OECD countries is significantly negative; however, as the government implements policies to counteract the negative effects, population ageing is expected to be associated with an increase in net FDI inflows (% of GDP) in the long-run. Generally speaking, as a country's population ages, raising the retirement age and increasing labor force participation, investing in capital and increasing labor productivity of the elderly workers, reforming the immigration laws and hiring more foreign workers for employment in industrial sectors for which domestic labor is not readily available, could be some of the policy measures that may be applied to mitigate the negative long-run effects of population ageing on the net FDI inflows (% of GDP).

The analysis would have been more interesting if we could have included real interest rate as an explanatory variable in the model; unfortunately, data on that variable is not readily available for all 20 OECD countries. We were constrained also by the lack of time series data on other potential determinants of FDI inflows, such as labor cost, tax, tariff, political stability, research and development expenditures (% of GDP), amongst others. However, that should not be of major concern as the main objective of this study is to investigate the existence of a cointegrating relationship between population ageing and FDI inflows (% of GDP) in OECD countries that are currently faced with the problem of population ageing.

Most studies have focused on economic factors as determinants of FDI inflows. Little attention has been given to demographic factors as potential determinants of FDI inflows, especially in cointegration analysis with structural breaks. This study has identified demographic trend as a significant determinant of FDI inflows for each of the 20 OECD countries under study. The sign and the statistical significance of the coefficients are country-specific. The results of our study could be used to design a macroeconomic policy framework aimed to attract FDI for sustainable economic growth in the OECD countries that are faced with the problem of population ageing.

References

Arslanalp, S., Lee, J. and U. Rawat (2019) "Demographics and interest rates in Asia", *Japan and The World Economy* **50**: 14-24.

Bai, J and P. Perron, P (1998) "Estimating and Testing Linear Models with Multiple Structural Changes", *Econometrica* **66**: 47-78.

Bai, J and P. Perron (2003) "Computation and Analysis of Multiple Structural Change Models", *Journal of Applied Econometrics* **18**: 1-22.

Barro, R. J., Mankiw, N. G. and X. Sala-i-Martin (1995) "Capital Mobility in Neoclassical Models of Growth", *American Economic Review* **85**, 103-115.

Carvalho, C., Ferrero, A., and F. Nechio (2016) "Demographics and real interest rates: Inspecting the mechanism", *European Economic Review* **88**: 208-226.

Emerson, P. and S. Knabb (2019) "A demographic headwind: Will an aging society reduce the real interest rate and potential growth?", *The Journal of the Economics of Ageing* **17**: 100190.

Head, K. and J. Ries (2005) "Judging Japan's FDI: The verdict from a dartboard model", *Journal of the Japanese and International Economies* **19**, 215–232.

Hibbard, S., Shultz, F., Wouters, L., and J. Zelezny (2009) "How the environment for foreign direct investment in Japan is changing – for the better" Knowledge@Whartonhttp://knowledge.wharton.upenn.edu/article.cfm?articleid=2212.

Ikeda, D. and M. Saito (2014) "The effects of demographic changes on the real interest rate in Japan", *Japan and the World Economy* **32**: 37-48.

Knickerbocker, F. T. (1973) "Oligopolistic Reaction and Multinational Enterprise" Boston: Harvard University Press.

MacDougall, G.D.A. (1960) "The benefits and costs of private investment from abroad: a theoretical approach", *Economic Record* **36**: 13-35.

Mitra R., Guseva M.E. (2021) "Does Population Ageing Reduce FDI Inflows in OECD Countries? Evidence from Bayesian Panel VAR Estimates". In: Mishra A.K., Vinzé A.S., Gupta R.S., Menon R. (eds) Advances in Innovation, Trade and Business. Contributions to Management Science. Springer, Cham. https://doi.org/10.1007/978-3-030-60354-0_6.

Mitra, R., and M.T. Abedin (2020) "Population Ageing and FDI Inflows in Japan: ARDL Approach to Cointegration Analysis", *Economics Bulletin* **40**:1814–1825.

Mitra, R. and M.T. Abedin (2021) "Population Ageing and FDI Inflows in OECD Countries: A Dynamic Panel Cointegration Analysis", *Applied Economics Letters* **28**: 1071-1075.

Mitra, R. and M.T. Abedin (2022) "Does a Shrinking Labor Force Reduce FDI Inflows in OECD Countries?", *Applied Economics Letters*, forthcoming.

Narciso, A. (2010) "The Impact of Population Ageing on International Capital Flows." MPRA Paper 26457, Germany: University Library of Munich.

Papetti, A. (2021) "Demographics and the natural real interest Rate: historical and projected paths for the euro area", *Journal of Economic Dynamics & Control* 132: 104209.

Pesaran, H.M. and B. Pesaran, B (1997) Microfit 4.0. Oxford University Press, Oxford.

Pesaran, M.H. and Y. Shin (1999) "An autoregressive distributed lag modelling approach to cointegration analysis, Econometrics and Economic Theory in the 20th Century", the Ragnar Frisch Centennial Symposium, Cambridge University Press.

Pesaran, M. H., Shin, Y. and R. J. Smith (2001) "Bounds testing approaches to the analysis of level relationships", *Journal of Applied Econometrics* **16**, 289-326.

Tomohara, A. (2017) "Does Immigration Crowd Out Foreign Direct Investment Inflows? Tradeoff between Contemporaneous FDI-immigration Substitution and Ethnic Network Externalities", *Economic Modelling* **64**: 40–47.

Zebregs, H. (1998) "Can the Neoclassical Model Explain the Distribution of Foreign Direct Investment Across Developing Countries?", IMF Working Paper No. 98/139, Available at SSRN: https://ssrn.com/abstract=882702.

Zivot, E. and D. Andrews (1992) "Further evidence of great crash, the oil price shock and unit root hypothesis", *Journal of Business and Economic Statistics* **10:** 251-270.