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RESEARCH ARTICLE

The Migration Dilemma in G8 Countries: Analysis with the TAR Model

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Abstract

Developed countries implement migration policies to mitigate the negative effects of aging populations. While such policies can have positive economic impacts for the receiving countries, migrants often face difficulties in social and cultural adaptation. The migration policies of G8 countries illustrate this dilemma in various ways. Although countries that consider migration an effective policy tool have greater potential to manage the challenges of aging populations, it is crucial to maintain social and political balance during this process. Efforts to alleviate the effects of population aging, along with the socioeconomic costs borne by migrants, lead to non-linear changes in migration patterns. Given these non-linear dynamics, evaluating migration thresholds becomes particularly important.

This study aims to estimate the optimal migration level that can help manage this dilemma. Specifically, it seeks to determine the maximum number of migrants that aging G8 countries can absorb using TAR models. One key finding is that migration flows below a certain threshold can positively influence the country's absorption capacity and enhance labor productivity as younger migrants enter the workforce. The policy recommendations derived from these results are expected to provide valuable guidance to policymakers. Implementing these recommendations can help maintain economic stability while leveraging the benefits of migration to address the challenges posed by an aging population.

Keywords

Population Ageing, Migration, Threshold Autoregressive Model, Old Dependency Rate, Group 8 Countries

JEL codes: F22, C24, J11, O52, O51

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Introduction

The aging population in developed countries poses significant challenges to economic growth and financial stability, as observed worldwide (Maestas, Mullen, and Powell 2023; Mason and Lee 2022; Gu, Andreev, and Dupre 2021; Smulyanskaya 2020; Koç and Solmaz 2019). Fertility rates – the primary determinant of population aging – remain below the replacement level, leading to a decline in the working-age population. One of the key strategies to mitigate the short-term effects of this demographic shift on the labor market is to leverage international migration (Pugliese and Ray 2011; Czaika and de Haas 2014; Bou-Habib 2018).

In the short term, a decrease in migration or an increase in out-migration can reduce net international migration. However, as the economy gradually recovers, the demand for labor is likely to persist, especially as the population continues to age (Rees et al. 2013). Maintaining the working-age population under these conditions will require a substantial increase in net migration (Craveiro 2019). Migration therefore emerges as a potential solution to this challenge, as migrants help fill gaps in the labor force.

Given the persistently low fertility rates in most developed countries (Ertürk and Koç 2023), net migration has increasingly become the main driver of population growth. If current trends continue, net migration is projected to account for all population growth in the developed world by 2050 (Zaiceva and Zimmermann 2016).

The precise effects of demographic changes and international migration on the economy and society in both receiving and origin countries are difficult to predict (Stepanek 2022). Beyond direct demographic impacts, such as contributing to population growth and shifting the age distribution toward younger cohorts, migration can also temporarily increase fertility in receiving countries. Migrants typically have higher fertility rates than natives upon arrival, although fertility tends to decline in subsequent generations.

Given the shrinking working-age population, particularly in Europe, and the generally young age profile of migrants, migration is often selective. Migrants are likely to integrate into labor markets and contribute to public budgets in the host country (Fargues 2014).

While migration is an effective tool for mitigating the negative effects of population aging (Aksoy and Zoega 2020), the variation in migration policies among developed countries affects migrant preferences. Countries with more pro-immigration policies are more likely to attract migrants. Within the G8 countries (Germany, France, Italy, the UK, Japan, Russia, the USA, and Canada) – the sample for this study – migration intake is guided by selective and relatively flexible strategies. Differences in policy design shape both the scale and the composition of migration, thereby influencing migrants' destination choices.

For example, Canada employs a human capital–based selection system that prioritizes education and skills, contributing to the inflow of highly qualified migrants (Koslowski, 2013; Schiff, 2014). In contrast, the United States relies primarily on labor demand–driven mechanisms aimed at addressing specific labor market needs (Koslowski, 2013; Canaan, 2021). Overall, more open and skill-oriented admission systems are associated with larger and more economically targeted migration inflows, enhancing migrants' potential contribution to receiving economies.

Migration policies in G8 countries play a crucial role in achieving both demographic and economic objectives. Germany seeks to alleviate pressure on the labor force resulting from an aging population by focusing on attracting skilled labor (Börsch-Supan 2003). Similarly, France encourages the growth of its younger population by emphasizing the integration

and social cohesion of migrants (French Ministry of the Interior 2020). Italy, in contrast, aims to attract migrant labor to counter low fertility rates and population aging but faces challenges in successful integration (Näre 2013). Despite its traditionally strict immigration policies, Japan has recently introduced some flexibility to address labor shortages (Bertram 2000). Russia attempts to mitigate its demographic challenges by attracting migrants from former Soviet countries (Mkrtchyan 2019; Selezneva and Sinyavskaya 2024). These policies contribute to improving demographic balances in receiving countries and supporting economic growth.

The effectiveness of these policies in G8 countries helps mitigate the negative impacts of aging populations while fostering economic growth. However, continuous evaluation and refinement of migration policies are essential to achieving long-term demographic and economic objectives. For these countries, identifying an optimal level of immigration is critical to sustaining both economic and demographic stability. For example, Canada's annual immigration targets are aligned with national economic growth and demographic balance goals (Green and Green 2004). Germany similarly focuses on attracting skilled labor to reduce pressure on its aging workforce (Hüfner and Klein 2012). In the United States, immigration quotas are set according to labor market requirements while accounting for the economic contributions of immigrants (Peri 2016). Collectively, these examples illustrate how G8 countries can utilize migration policies to mitigate the negative effects of population aging and support sustained economic growth.

This study aims to determine the optimal number of migrants in G8 countries using the Threshold Autoregressive (TAR) model, with the elderly dependency ratio and net migration values as key determinants of population aging. Understanding the time-varying nature of migration and its economic effects is particularly complex in large economies such as the G8 countries. TAR models account for both time dependence and threshold effects when assessing the impact of migration on economic growth, labor markets, and public finances. By analyzing the effects of migration on economic and social systems over different periods, these models can capture potential changes that occur when specific thresholds are crossed. This approach is therefore an important tool for informing migration policies and determining optimal migration levels.

In this context, the study's hypothesis posits that it is possible to determine the optimal number of migrants in G8 countries by linking net migration values with the old-age dependency ratio, a key indicator of population aging, through the TAR model. Specifically, the hypothesis seeks to examine how net migration responds to increases in the old-age dependency ratio and how exceeding certain threshold values may affect the effectiveness of migration policies.

Although many countries have attempted to limit migration flows in recent years, demographic dynamics – such as population aging and declining fertility rates – have led to significant population reductions. These demographic shifts create substantial gaps in the labor market, which can be addressed through immigration (United Nations 2019; Lee and Mason 2011). However, excessive immigration may disrupt socio-economic structures in host countries and generate social tensions (Dustmann and Frattini 2014). To address this dilemma, this study aims to identify the optimal level of immigration that balances economic sustainability with social cohesion. By doing so, it seeks to inform policy development that supports both demographic and economic stability.

Following this introduction, the study proceeds with a literature review. The third section outlines the data and methodology, the fourth presents the results, and the final section concludes with the overall findings and policy implications of the study.

Literature Review

Population aging is a global demographic transformation with profound effects on the economic, social, cultural, and political structures of societies (Hatton and Williamson 2005). It can have both positive and negative implications for economic growth (Aras and Crowther 2012; Yuan and Gao 2020; Chomik and Piggott 2021). In addition, migration can help mitigate some of these challenges in the short term by preventing declines in labor supply and alleviating pressure on social security systems resulting from population aging. Accordingly, there is a growing body of literature examining migration movements and their effects (Marois et al. 2020; Peng 2021; Wu et al. 2021; Ciobanu et al. 2020).

Including immigration among policies aimed at sustaining labor supply is of strategic importance. Developing policies to attract young migrants supports economic productivity by addressing labor shortages (Zimmermann 2005). Gagnon (2014) notes that such policies can encourage human capital accumulation in OECD and EU countries and positively influence economic growth. Moreover, the presence of highly educated immigrants tends to have a stronger effect on economic growth (Oliinyk et al. 2021). Therefore, creating favorable conditions for the migration of highly educated individuals and implementing appropriate public policies is essential.

Migration has increasingly become a major driver of population growth in many developed countries. Hanson and McIntosh (2016) analyze the impact of demographic trends on migration to Europe and the United States and provide forecasts based on these trends. They argue that the earlier decline in fertility in the United States relative to Mexico contributed to increased migration from Mexico to the United States during the 1980s, followed by a subsequent slowdown in the growth of younger generations in Mexico. Their demographic-based forecasts suggest that migration from Mexico to the United States will decline in the coming decades, while migration from Africa and the Middle East to Europe is expected to rise significantly.

Studies have examined both developed and developing countries. For example, Mayda (2010) finds that the proportion of the young population in the source country had a positive and significant effect on migration rates in OECD countries from 1980 to 1995. Similarly, Efendic (2016) emphasizes that youth is the most critical individual characteristic influencing future migration in Bosnia and Herzegovina between 2002 and 2010. Clemens and Mendola (2024) provide individual-level estimates of immigrant self-selection for 99 developing countries, assessing both observed and unobserved income determinants.

For migration to have positive effects on population aging and economic growth, it is essential to determine the optimal level of migration and to balance its impact on the social and demographic structures of countries. In this context, studies explicitly focused on identifying the optimal migration level are limited. Existing research can be broadly categorized into studies that directly and indirectly estimate optimal migration levels.

Studies that directly determine the optimal level of migration (Borjas 1999; Ortega and Peri 2009; Facchini and Maya 2009; Ruhs and Martin 2008) primarily focus on the factors that countries should consider when setting migration targets and on regulating migration at levels that contribute positively to the economy. Key factors include the effects of migrants on the labor market, wage levels, and overall welfare, which are crucial in determining an optimal migration level.

Studies that indirectly assess optimal immigration levels (Dustmann and Preston 2019; Aiyar and Ebeke 2016; Clemens 2011) typically examine the impact of a given level of immigration on economic productivity and labor market outcomes. These studies also discuss how migration levels can be optimized and which policies can generate welfare gains.

Several studies employ economic modeling to quantify optimal migration. Chojnicki and Ragot (2016) use a general equilibrium model to determine the optimal immigration level for countries, highlighting the positive effects of immigrant labor force participation and productivity on economic growth, as well as contributions to social security systems. Boubtane, Dumont, and Rault (2016) analyze the effects of migration on economic growth, particularly in OECD countries, and emphasize that immigrant participation in the labor force and entrepreneurship promotes economic growth, making it a key factor in determining optimal migration levels. Similarly, Lee and Miller (2000) employ an economic model to estimate optimal immigration levels for the United States, evaluating the effects of immigrants on labor force participation and public services. Their results indicate that maintaining a certain level of immigration is critical for promoting economic growth and sustaining social equilibrium.

An analysis of the literature reveals that studies explicitly addressing the optimal level of migration are relatively limited. Rather than focusing directly on the "optimal amount of migration," most studies examine migration within the framework of balancing its economic, social, and political effects, as well as the macroeconomic consequences of migration policies. The topic has also been addressed indirectly in research on the economic, social, and demographic impacts of migration.

Nevertheless, determining the optimal level of migration is crucial for ensuring economic and social sustainability. Unbalanced implementation of migration policies may slow economic growth, disrupt social cohesion, and place pressure on public services. In recent years, identifying the optimal number of migrants has become particularly important for mitigating the negative economic effects of population aging caused by declining fertility rates, especially in developed countries. Aligning migration levels with economic needs, demographic trends, social cohesion, and public service capacity is recognized as a fundamental strategy for effective migration management.

In this context, the contribution of this study is to enhance understanding of the dynamics of migration over time and its effects under changing economic conditions by estimating the optimal level of migration in developed countries. Understanding how migration affects economic growth, labor market dynamics, and social systems over time is of critical importance for policymakers, particularly in large economies such as the G8 countries.

Data and Methods

Method

Migration is inherently non-linear due to multiple interacting processes, including demographic, climatic, and economic factors (McKenzie and Rapoport 2007). Changes in the expansion, recovery, and contraction phases of the adaptation process underlying migration dynamics are often asymmetric. These asymmetric diffusion mechanisms alter the dynamics of the linear autoregressive (AR) processes traditionally used in ARMA and ARIMA models

within the Box-Jenkins framework[1]. As the dynamics of these processes evolve over time, nonlinear models are required to accurately capture asymmetric fluctuations in the variables (Wu et al. 2011).

Nonlinear models allow AR parameters to switch between different states within each process through piecewise linear regressions (Tong and Lim 1980). The first study on regime-switching models within the framework of piecewise linear regressions was conducted by Quandt (1958). Building on this foundation, Tong and Lim (1980) developed the univariate Threshold Autoregressive (TAR) model. The TAR model is widely regarded as a powerful tool for capturing and analyzing time-dependent, nonlinear changes in a process. A general representation of the TAR model is constructed as follows:

$$y_t = \alpha_0 + \sum_{i=1}^{p} (\alpha_i y_{t-i}) I\left(s_{t-d} \leq c\right) + (\beta_0 + \sum_{i=1}^{p} \beta_i y_{t-i}) I\left(s_{t-d} > c\right) + \varepsilon_t. \tag{1}$$

In the TAR model, y_t denotes the dependent variable, s_{t-d} is the threshold variable that triggers a regime change, c is the threshold value, α_0 and β_0 are fixed parameters, d is the lag parameter, $I_t(c)$ is the indicator function, and ε_t is an independently and identically distributed (i.i.d.) error term. The indicator function is defined as $I = 1$ if the threshold condition is satisfied, and $I = 0$ otherwise. Since the series follows an AR process with parameters α_0 and α_i when the threshold variable s_{t-d} is less than or equal to the threshold value c, and a different AR process with parameters β_0 and $\beta_i > s_{t-d}c$, the TAR model can be explicitly represented as follows:

$$y_t = \begin{cases} \alpha_0 + \sum_{i=1}^{p} \alpha_i y_{t-i} + \varepsilon_{1t} & s_{t-d} < c, \\ \beta_0 + \sum_{i=1}^{p} \beta_i y_{t-i} + \varepsilon_{2t} & s_{t-d} > c. \end{cases} \tag{2}$$

The steps involved in constructing a TAR model can be summarized as follows. First, the lag length p for the linear AR model is determined using an information criterion such as the Akaike Information Criterion (AIC) or the Schwarz Bayesian Criterion (SBC). Next, the lag parameter d is selected by performing a nonlinearity test for each lag separately, and identifying the lag for which nonlinearity cannot be rejected. Finally, the threshold number and threshold value are determined, and the model is estimated by constructing separate linear models for each regime (Akgül and Koç 2011).

The linearity of the process is tested using an F-test. Subsequently, the null hypothesis of no threshold effect is evaluated. Once the threshold value is estimated, the procedure is completed by constructing the appropriate TAR model.

1 The Autoregressive (Autoregressive – AR) Model was first proposed by Udny Yule in 1927. Yule (1927) defined autoregressive (AR) processes in which the current value of a time series is expressed as a linear combination of its past values. In these models, the current value of the series consists of the weighted sum of a certain number of previous values and an error term. Yule used autoregressive models, known as Yule-Walker, especially in his studies on sunspots and economic time series. Later, Wold (1938) contributed to time series analysis, but the full development and modern use of the autoregressive model was made by Box and Jenkins in the 1970s. In particular, the Box-Jenkins Method popularized the ARMA and ARIMA models.

Data

In this study, the elderly dependency ratio is used as the threshold variable to examine the effects of exceeding (or falling below) a certain rate on net migration values. The old-age dependency ratio (OADR) is a widely used measure developed by demographers to represent the relationship between the working-age population (usually ages 15–64) and the dependent population outside the working age (under 15 and over 64). The OADR provides a simple yet effective indicator of how old a society is and is a standard reference measure in both academic and policy literature on aging worldwide due to its ease of interpretation (Basten 2013).

In recent years, several European countries have alleviated demographic pressure through high net migration rates, largely driven by refugees from regions affected by civil conflicts in the Middle East (Klingseis 2016). In this context, it is important to explore and compare country-specific net migration rates alongside core population aging indicators (Jakovljevic et al. 2018). This study aims to provide novel insights by estimating optimal migration rates to mitigate challenges associated with population aging in G8 countries.

For this purpose, 63 annual observations for both variables from 1960 to 2022 were obtained from the World Bank World Development Indicators for eight developed countries (G8 countries).

Table 1 presents the descriptive statistics of the variables for the G8 countries. Russia has the lowest average elderly dependency ratio (17.31), whereas Germany exhibits the highest ratio. Canada (0.376) and France (0.374) show the highest average net migration rates, indicating that they are attractive destinations for immigrants. Canada's high standard deviation (0.0619) reflects significant fluctuations in migration rates. Italy (-0.114) and Russia (-0.114) experienced net migration losses, with Italy's minimum value (-0.290) highlighting substantial outflows. Germany's average net migration rate (0.205) indicates a relatively stable migration structure, supported by a low standard deviation (0.010). The United Kingdom (-0.114) has experienced net migration losses, with the impact of post-Brexit migration policies clearly evident.

The changes in net migration for G8 countries during the analysis period are presented in Figure 1. These changes do not follow a linear trend and are influenced by factors such as migration policies and the economic conditions of each country.

Canada's net migration rate has generally been positive and has increased significantly since the 1990s. Germany's net migration rate began rising in the late 1980s and has remained high since the 2010s. Italy experienced positive net migration rates from the 1980s, although these declined in the 2010s. France's net migration rate was high and relatively stable during the early 2000s. Japan, consistent with its strict immigration policies, has maintained generally low and occasionally negative net migration rates. In Russia, net migration was negative in the early 1990s but became positive and reached high levels from the 2000s onward. The United Kingdom has experienced an upward trend in net migration since the 1990s, with rates generally remaining positive. The United States has consistently had high and positive net migration rates, although a decline was observed in 2020 and 2021.

These observations highlight the influence of migration policies, economic conditions, and global events on migration flows across G8 countries.

Figure 2 presents the elderly dependency ratios of the G8 countries. Following the retirement of the baby boomer generation (born 1946–1964), the elderly dependency ratio began to rise in all G8 countries after the 2000s.

Table 1. Basic Statistics

Country	Net Migration				Old-Age Dependency Rate			
	Mean	St. Error	Min	Max	Mean	St. Error	Min	Max
Germany	0.2052	0.0102	0.1378	0.2319	24.86	4.87	17.1	35.22
France	0.3739	0.0110	-0.3058	0.4110	23.87	4.37	18.79	35.42
Italy	-0.1169	0.0272	-0.2900	-0.0551	24.3	6.9	14.52	37.87
United Kingdom	-0.03265	0.0062	-0.0483	0.0044	23.63	2.9	18.06	30.25
United States	0.2682	0.0169	0.1718	0.3301	18.48	2.56	15.39	26.38
Russia	-0.1144	0.0106	-0.1598	-0.0533	15.91	3.68	9.57	23.75
Canada	0.3762	0.0619	0.1323	0.6782	17.31	4.4	12.83	29.1
Japan	0.0327	0.0177	-0.049	0.1137	23.53	13.6	8.96	51.19

Sources: The variables used in this study were obtained from the World Bank Databank. Annual data on net migration rates and the elderly dependency ratio cover the period from 1960 to 2022. Net migration rates were calculated by dividing the net number of migrants in each country by the total population. The old-age dependency ratio is defined as the ratio of elderly dependents (persons aged over 64) to the working-age population (ages 15–64) and is expressed as the number of dependents per 100 working-age individuals. Table 1 was constructed based on the authors' calculations using the EViews 10.0 software.

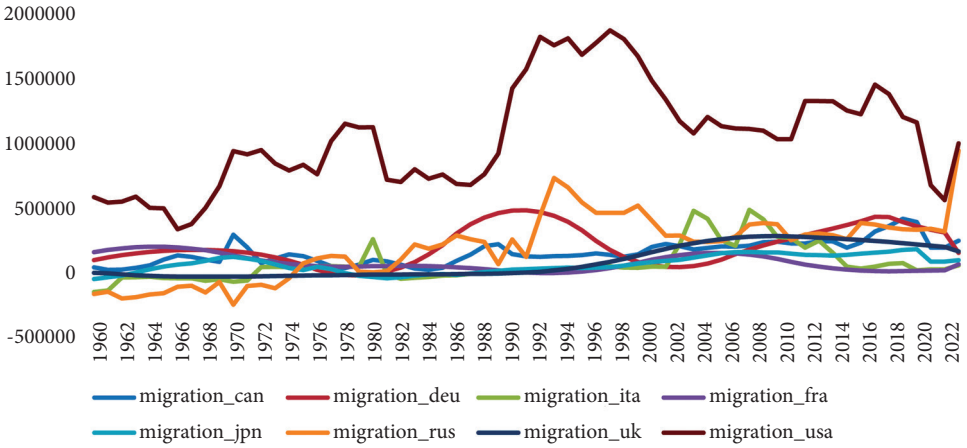


Figure 1. Net Migration of Countries. *Source:* The variables used in this study were obtained from the World Bank Databank. Net migration was calculated by subtracting the number of emigrants, including both citizens and foreigners, from the number of immigrants. Figure 1 was created based on the authors' calculations using Microsoft Excel. The legend below the graph in Figure 1 corresponds to the following countries: migration_can – Canada; migration_deu – Germany; migration_ita – Italy; migration_fra – France; migration_jpn – Japan; migration_rus – Russia; migration_uk – the United Kingdom; migration_usa – the United States.

In Canada, the elderly dependency ratio has increased steadily since the 1980s and accelerated in the 2020s, reaching approximately 29 percent. Germany's ratio has risen rapidly since the early 1990s, exceeding 35 percent in the 2020s. Italy experienced a similar trend, with its elderly dependency ratio approaching 37 percent in the 2020s. France's ratio increased more gradually but still surpassed 30 percent in the 2020s. Japan has the highest elderly dependency ratio among the G8 countries, rising sharply since the 1980s and exceeding 50 percent in the 2020s. In Russia, the elderly dependency ratio has grown steadily since the 1990s, reaching 23 percent in the 2020s. The United Kingdom's ratio increased consistently from the 1980s, reaching around 30 percent in the 2020s. The United States started with a lower ratio but experienced growth to 26 percent in the 2020s.

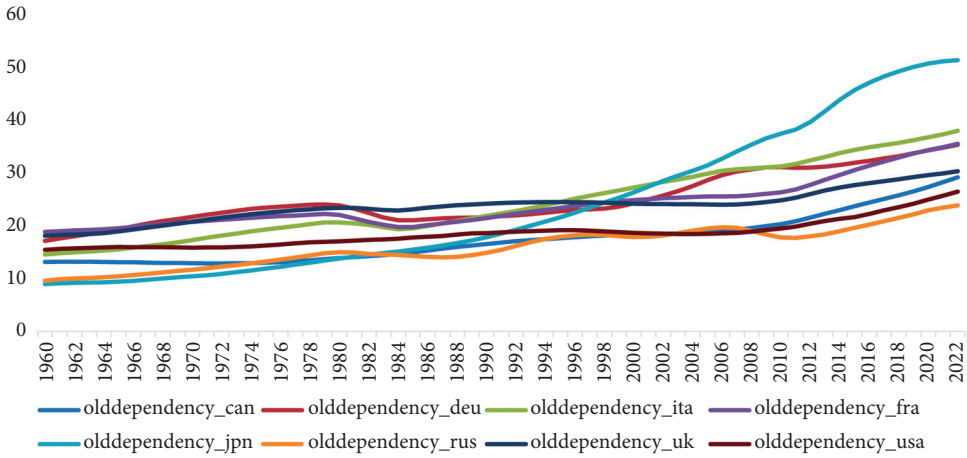


Figure 2. Old-Age Dependency Ratio of Countries. *Source:* Figure 2 was generated based on the authors' calculations using Microsoft Excel. The legend below the graph in Figure 2 corresponds to the following countries: olddependency_can – Canada; olddependency_deu – Germany; olddependency_ita – Italy; olddependency_fra – France; olddependency_jpn – Japan; olddependency_rus – Russia; olddependency_uk – United Kingdom; olddependency_usa – United States.

Empirical Analysis

This study employs the Threshold Autoregressive (TAR) model, a nonlinear econometric time series model, to examine the relationship between net migration and the elderly dependency ratio and to identify the most appropriate threshold value for this relationship. The analysis aims to determine how countries may need to adjust their migration policies when the elderly dependency ratio is below or above a certain threshold, in order to mitigate the negative effects of population aging.

In line with the objectives of this study, the analysis begins with unit root tests to assess the stationarity of the data. Subsequently, the Brock-Dechert-Scheinkman (BDS) test (Brock et al. 1996), a widely used test for nonlinearity, is applied to determine the suitability of using the TAR model. Once the results confirm the presence of nonlinearity in the variables, the TAR model is implemented. Following the estimation, diagnostic tests are conducted to ensure the validity of the model, and the results are subsequently interpreted.

Unit Root and BDS Test Results

Table 2 presents the results of the unit root tests for the variables. For net migration, all variables became stationary after taking the first difference at the 5% significance level, except for France and the United Kingdom. Regarding the elderly dependency ratio, Italy became stationary after the first difference, while all other countries required a second difference to achieve stationarity.

Unit root tests were performed with a constant term for all countries. However, it was observed that Canada's elderly dependency ratio was stationary even in the test without a constant term.

Table 2. Results of Unit Root Test

Variables	Countries	D(0)		D(1)		D(2)	
		t-statistic*	Prob	t-statistic*	Prob	t-statistic*	Prob
Net Migration	Canada	-2.00	0.28	-5.47	0.00		
	Germany	-2.06	0.25	-3.42	0.01		
	France	-4.29	0.00				
	Italy	-2.71	0.07	-7.76	0.00		
	Japan	-1.75	0.39	-5.40	0.00		
	Russia	-1.02	0.73	-6.39	0.00		
	United Kingdom	-3.08	0.03				
	United States	-1.81	0.37	-5.67	0.00		
Old Dependency	Canada**	2.52	1.00	-0.77	0.81	-2.08	0.03
	Germany	0.26	0.97	-2.08	0.25	-5.48	0.00
	France	-2.18	0.99	-1.26	0.64	-4.90	0.00
	Italy	1.89	0.00	-3.63	0.00		
	Japan	-1.70	0.42	-1.79	0.38	-7.42	0.00
	Russia	-0.26	0.92	-5.42	0.00		
	United Kingdom	0.49	0.98	-2.03	0.27	-3.62	0.00
	United States	1.13	0.99	-0.03	0.99	-3.67	0.00

Notes: Table 2 is obtained from the authors' calculations with the EVİEWS 10.0 software. The critical values for the t-statistics in the unit root tests are as follows: with intercept: %1–3.54; %5–2.91; %10–2.59** without intercept (none): %1–2.09; %5–1.94; %10–1.61 Appendix 1 presents the results of the BDS test. According to these results, during the analysis period, both net migration and elderly dependency ratios exhibit non-linear behaviour for all countries except the USA. Since the null hypothesis of linearity could not be rejected for the USA, this country is excluded from the subsequent TAR analysis.

Analysis Results

In this study, the relationship between net migration and the elderly dependency ratio is examined using the TAR model for the G8 economies. The results show that the elderly dependency ratio exerts statistically significant effects on net migration once it crosses specific threshold values. These findings indicate that the impact of migration differs across

countries and varies according to the level of population aging, implying that migration policies should be dynamically adjusted in line with demographic pressures. Table 3 below presents the estimated coefficients and key statistical indicators of the TAR model for each country included in the analysis.

Table 3. Results of the TAR Model

Country	Variable	Coefficient	Std. Error	t-Statistic	p-Value
Italy	olddependency < 28.6743				
	Coefficient	-131150.0	61695.47	-2.1257	0.0379
	Olddependency	6580.631	3098.670	2.1236	0.0381
	Migration (-1)	0.3229	0.1200	2.68	0.0094
	28.67431 <= olddependency				
	Coefficient	1419139.	338098.3	4.197416	0.0001
	Olddependency	-38990.40	9549.350	-4.083042	0.0001
	Migration (-1)	0.310001	0.170552	1.817629	0.0745
Canada	olddependency < 13.0455 – 9 obs				
	Olddependency	-800149.6	310842.3	-2.574134	0.0129
	Coefficient	10612946	4044871.	2.623803	0.0113
	Migration (-2)	-0.768626	0.213608	-3.598291	0.0007
	13.0455 <= olddependency – 52 obs				
	Olddependency	10046.21	2371.869	4.235570	0.0001
	Coefficient	-88780.62	29493.21	-3.010206	0.0040
	Migration (-2)	-0.657731	0.140610	-4.677693	0.0000
Germany	olddependency < 20.99183 – 9 obs				
	Olddependency	23073.66	9658.088	2.389051	0.0207
	Coefficient	-254001.9	139822.6	-1.816601	0.0753
	Migration (-1)	-0.178435	0.456868	-0.390562	0.6978
	20.99183 <= olddependency < 22.89157 – 18 obs				
	Olddependency	-58572.65	9583.364	-6.111909	0.0000
	Coefficient	1307243.	208859.0	6.258975	0.0000
	Migration (-1)	0.934680	0.031077	30.07634	0.0000
	22.89157 <= olddependency < 31.40877 – 26 obs				
	Olddependency	11593.07	1477.846	7.844567	0.0000
	Coefficient	-284343.8	36667.35	-7.754685	0.0000
	Migration (-1)	0.807114	0.045170	17.86829	0.0000
	31.40877 <= olddependency – 9 obs				
	Olddependency	-35335.94	6265.276	-5.639966	0.0000
	Coefficient	1114645.	248475.0	4.485945	0.0000
	Migration (-1)	1.100928	0.196102	5.614067	0.0000

Country	Variable	Coefficient	Std. Error	t-Statistic	p-Value
France	olddependency < 20.67183 – 14 obs				
	Olddependency	-19250.91	3741.262	-5.145566	0.0000
	Coefficient	383694.8	75359.22	5.091544	0.0000
	Mıgratıon (-1)	0.964135	0.027200	35.44569	0.0000
	20.67183 <= olddependency < 25.47134 – 30 obs				
	Olddependency	7370.451	754.0139	9.774954	0.0000
	Coefficient	-161032.6	16920.70	-9.516895	0.0000
	Mıgratıon (-1)	0.921975	0.025237	36.53265	0.0000
Japan	olddependency < 14.49814 – 21 obs				
	Olddependency	-8559.669	2235.067	-3.829715	0.0003
	Coefficient	99068.52	25346.87	3.908511	0.0003
	Mıgratıon (-1)	0.884126	0.069868	12.65423	0.0000
	14.49814 <= olddependency – 41 obs				
	Olddependency	-195.6046	418.9514	-0.466891	0.6424
	Coefficient	12823.96	8345.820	1.536572	0.1300
	Mıgratıon (-1)	0.957575	0.075519	12.67990	0.0000
Russia	Olddependency	20464.78	6338.104	3.228848	0.0020
	Coefficient	-249389.9	88613.57	-2.814353	0.0066
	Mıgratıon (-1)	0.678470	0.099777	6.799839	0.0000
UK	olddependency < 24.10017 – 37 obs				
	Olddependency	1339.812	566.2713	2.366025	0.0215
	Coefficient	-28009.13	12402.13	-2.258413	0.0278
	Mıgratıon (-1)	1.050533	0.011527	91.13677	0.0000
	24.10017 <= olddependency – 25 obs				
	Olddependency	-4523.695	649.2542	-6.967525	0.0000
	Coefficient	126387.0	15952.78	7.922567	0.0000
	Mıgratıon (-1)	0.963135	0.013063	73.73144	0.0000

Notes: The results show how changes in the threshold variable, the old-age dependency ratio, affect the dependent variable, the net migration rate.

In the TAR model, the signs of the coefficients in different regimes indicate the direction of the independent variable's effect on the dependent variable. A positive coefficient in one regime and a negative coefficient in another implies that the impact of the variable changes once the threshold is crossed, demonstrating that the model operates under different dynamics across regimes. This provides important insights into the structural asymmetries within the time series. In this context, the results for Italy show that the old-age dependency ratio has a strong and positive effect on net migration when it exceeds the estimated threshold. This finding is in line with the arguments of Borjas (1999) and Ortega and Peri (2009), who suggest that migration can contribute to economic sustainability by filling labour short-

ages. The observation that migration increases as the old-age dependency ratio rises in Italy supports the view that migration serves as a corrective mechanism for labour gaps created by population aging. However, the results also indicate negative effects in the regime where migration remains below a certain level. This is consistent with studies such as Dustmann and Frattini (2014), who highlight that both the quantity and the quality of migration flows matter for achieving positive socio-economic outcomes.

The negative effect of the old-age dependency ratio on net migration in Canada at lower levels supports the view that demographic dynamics play a decisive role in shaping economic outcomes, as suggested by Lee and Mason (2011) and the United Nations (2019). Canada is among the advanced economies experiencing declining fertility rates and population aging. In this context, the finding that the old-age dependency ratio exerts a positive effect on net migration after a certain threshold indicates that immigration becomes increasingly critical for sustaining labour market needs. This result aligns with the arguments of Borjas (1999) and Ortega and Peri (2009), who emphasise the role of immigration in maintaining economic sustainability by compensating for labour shortages.

The results obtained for Germany similarly show that the positive and negative effects of the old-age dependency ratio on net migration vary across threshold values. Germany, as a country with a rapidly aging population, has relied on immigration to mitigate labour shortages. However, the findings indicate that when the old-age dependency ratio becomes excessively high, the effects of immigration may turn negative. This outcome is consistent with the arguments of Dustmann and Frattini (2014), who highlight that large and imbalanced migration flows can generate pressures on the socioeconomic structure of host countries.

In France, the negative effect on net migration when the old-age dependency ratio is low suggests that migration may generate imbalances in periods where labour demand is limited. However, as the old-age dependency ratio increases, the positive effect of demographic aging on net migration becomes more pronounced. This pattern supports the theoretical framework presented by the United Nations (2019) and Lee and Mason (2011), which argues that population aging increases the need for labour-market supplementation through immigration. The findings for France therefore indicate that migration becomes a more effective policy instrument once certain demographic thresholds are exceeded.

In Japan, a negative effect on net migration is observed when the old-age dependency ratio is low, while no statistically significant relationship emerges above the threshold value. This result is unsurprising given Japan's historically restrictive migration policies. Unlike other advanced economies discussed by Borjas (1999) and Ortega and Peri (2009), Japan has not relied heavily on immigration to mitigate labour shortages. Consequently, the relationship between migration and population aging appears weaker in Japan, reflecting the country's limited utilisation of migration as a demographic or economic adjustment mechanism.

In Russia, the results indicate that the old-age dependency ratio has a positive effect on net migration. This pattern resembles the dynamics commonly observed in developing countries, where migration is used strategically to address labour-market shortages. Russia's reliance on migrants – particularly from former Soviet republics – supports the argument put forward by Lee and Mason (2011), who emphasize the role of migration in mitigating the economic pressures associated with demographic aging.

In the United Kingdom, the findings reveal a complex, non-linear relationship. While the old-age dependency ratio has a positive effect on net migration at low levels, the effect becomes negative once the ratio surpasses the threshold. This shift highlights the tension

between demographic imbalances and migration policies. As Dustmann and Frattini (2014) suggest, migration can generate socioeconomic frictions, particularly when demographic pressures intensify. The UK case illustrates how rising old-age dependency may exacerbate concerns regarding social cohesion and labour-market adjustment, thereby reducing the positive impact of migration.

In the United States, the old-age dependency ratio positively affects net migration when the ratio is low; however, above a certain threshold, the relationship becomes statistically insignificant. Although the U.S. economy traditionally relies heavily on migrant labour, the diminishing marginal effect of demographic aging on net migration at higher levels suggests that structural or policy-related constraints may limit the responsiveness of migration flows. This result is consistent with Borjas (1999), who argues that the economic contribution of immigration may weaken over time as labour-market absorption capacity changes or policy priorities shift.

Table 4. Threshold Values of Countries

Countries	Threshold
Italy, Canada, Japan, United Kingdom	1
France	2
Germany	3
Russia	No Threshold

Notes: Table 4 was obtained by the authors by interpreting the results in Table 3.

The threshold values presented in Table 4 represent the levels of the old-age dependency ratio at which the relationship between the independent variable, net migration, and demographic aging shifts. These thresholds are estimated separately for each G8 country, reflecting their distinct demographic and policy environments. For Italy, Canada, Japan, and the United Kingdom, a single threshold value was identified, indicating that the effect of the old-age dependency ratio on net migration changes markedly once this critical level is exceeded. In France, two thresholds were detected, suggesting a more nuanced, multi-regime structure in which different stages of demographic aging exert varying effects on migration dynamics. Germany exhibits an even more complex pattern, with three thresholds, reflecting the country's multifaceted demographic challenges and the sensitivity of migration flows to shifts in the elderly population. In contrast, no threshold was identified for Russia, implying either that the old-age dependency ratio does not significantly influence net migration or that its effects are more evenly distributed across demographic levels. Overall, these threshold values provide important insights into how migration policies may need to be adjusted as the elderly population expands in each country.

This distribution highlights how net migration dynamics shift in developed economies when the elderly dependency ratio widens, structural patterns emerge across regimes, and key threshold values are exceeded. In countries such as Italy, Germany, Canada, and the United Kingdom, higher old-age dependency ratios intensify labour-market pressures, thereby increasing the economic importance of migration. This pattern aligns with previous studies such as Borjas (1999) and Ortega and Peri (2009), which emphasize that migration can support economic sustainability by mitigating labour shortages. However, the results also show that once certain demographic thresholds are surpassed, migration may

generate negative social and economic consequences. This is consistent with the concerns raised by Dustmann and Frattini (2014) regarding the risks of socioeconomic imbalances and rising social tensions. Overall, while existing theories remain broadly valid, the findings underscore the need for migration policies to remain dynamic and adaptable to changing demographic conditions.

Compared with developing countries, the relationship between migration and aging in the advanced economies examined here is both more pronounced and more complex. In many developing countries, old-age dependency ratios remain relatively low, meaning that migration pressures manifest differently and may influence labour markets through alternative mechanisms. This contrast suggests that developed economies require more frequent and detailed analyses to understand and sustain the balance between demographic aging and migration flows. The TAR model employed in this study proves to be an effective tool for capturing these nonlinear relationships and offers valuable insights for optimizing migration policies. Consequently, the findings contribute to the existing literature and highlight the importance of designing flexible, responsive migration policies that reflect each country's demographic and economic realities.

The economic effects of the elderly dependency ratio vary across countries according to the threshold values identified in the analysis. Among the European countries, Germany and France exhibit similar threshold values. In both countries, with elderly dependency ratios ranging between 20 and 25, the positive economic effects of population aging are initially observed as the ratio rises. However, once these thresholds are exceeded, the effects turn negative. In France, economic deterioration is more pronounced at lower levels of the elderly dependency ratio, whereas moderate levels of aging allow for greater stability and balance. In Germany, immigration plays a crucial role in mitigating the negative economic impacts of population aging, although this balancing effect diminishes when the ratio surpasses higher thresholds. At elevated threshold values, Italy experiences positive economic effects from the elderly dependency ratio, while in Germany the economic impact becomes negative. Nevertheless, in Germany, immigration continues to serve as an important stabilizing factor for the economy.

Canada and Japan, both characterized by high elderly dependency ratios, exhibit different economic outcomes at the identified threshold levels. In Canada, the economic effect of the elderly dependency ratio is negative at the threshold, but well-designed economic policies help to mitigate these impacts. In contrast, Japan benefits from the positive effects of immigration even when the ratio exceeds the threshold, which allows the country to largely neutralize the economic consequences of higher elderly dependency ratios. This demonstrates that Japan's policies and economic adaptations to an aging population are comparatively more effective than those of other countries. Meanwhile, although no specific threshold was identified for Russia, the results suggest that the elderly population generally contributes positively to the economy, and social expenditures are managed in a balanced manner.

Overall, the results suggest that in European countries, adaptation mechanisms are triggered once the elderly dependency ratio exceeds threshold values. However, the effectiveness of these mechanisms is limited over the long term. In contrast, countries such as Canada and Japan are able to implement adaptation processes successfully even at lower threshold levels, effectively leveraging immigration policies to mitigate demographic pressures. Migration emerges as a critical policy tool for balancing the negative economic and social effects of rising elderly dependency ratios in many countries. These findings indicate that the broader application of such policies could offer substantial benefits at a global level.

Conclusion

This study highlights the importance of determining how migration flows can be optimized according to threshold values of the old-age dependency ratio to address the economic and social challenges of an aging population. The aim of the study was to examine how migration levels can be aligned with the old-age dependency ratio in countries with aging populations without negatively affecting key economic indicators. As a result, important policy recommendations are presented to enhance the effectiveness of migration policies and support economic sustainability. Increasing labour productivity through the participation of young immigrants in the labour market is expected to have a positive impact on economic growth and public finances.

The hypothesis of the study is that if migration flows remain below a certain threshold, the number of immigrants a country can receive may increase, which in turn can boost labour market productivity. To test this hypothesis, the effects of migration on economic growth and labour market dynamics were analyzed in a time-dependent manner using threshold autoregressive (TAR) models.

The relationship between migration policies and the elderly dependency ratio creates an economic dilemma. Migration is a powerful tool that supports economic growth and mitigates the effects of an aging population; on the other hand, the integration of immigrants brings challenges such as social cohesion and cultural dynamics. Countries such as the United States and Canada have managed to turn this dilemma into an opportunity by accepting immigrants according to their economic needs. While these countries use immigration as a tool for economic growth, they have adopted flexible and multicultural policies to ensure social cohesion.

However, countries such as Japan, which have more restrictive immigration policies, are trying to address this dilemma differently. Japan prefers to manage the aging crisis with technological innovations and domestic economic regulations rather than immigration, but the long-term sustainability of this approach is debatable.

In continental Europe, this dilemma is more complex. Countries such as Germany, France, and Italy are attempting to address labour shortages through immigration, while simultaneously struggling with the social and political challenges of integrating immigrants. Countries such as Russia and the United Kingdom try to manage this problem regionally, relying on immigration from neighboring regions, but this policy can sometimes pose risks in terms of integration and the economic contributions of immigrants. The United Kingdom has become one of the clearest examples of this dilemma, particularly following the changes in its immigration policies after Brexit.

One of the main implications for policymakers is that the appropriate management and optimal level of migration flows play an essential role in mitigating the negative effects of aging populations. In this context, considering economic and social costs when defining migration policies is crucial for long-term sustainability. Analyses, particularly in the context of G8 countries, provide important insights into how migration policies should be designed by linking net migration values to the elderly dependency ratio.

Overall, the relationship between countries' migration policies and the elderly dependency ratio creates a dilemma that produces varying economic and social outcomes. Countries that effectively use migration as an economic tool gain a greater advantage in alleviating the burden of an aging population. However, this strategy also introduces complex issues related to social cohesion, security, and social policy. In this context, shaping migration policies is a

multidimensional process requiring careful consideration of economic, social, and cultural balances.

These findings offer guidance to policymakers on enhancing the effectiveness of migration policies and supporting economic growth objectives. Careful and balanced management of migration flows is critical for both economic and social sustainability. In this regard, the study presents a strategic roadmap for addressing population aging and promoting economic growth by highlighting the key principles that should guide the formulation and implementation of migration policies.

This study examined the relationship between the elderly dependency ratio and net migration in G8 countries and employed the TAR model to determine optimal migration levels. The analysis demonstrates that the elderly dependency ratio is a significant determinant of net migration and that migration dynamics change substantially when certain threshold values are exceeded. It was observed that migration plays an especially important role in the labour market and economic growth in countries with a high elderly population, such as Italy, Germany, and Japan. These findings confirm that migration can help close the labour force gap created by population aging in developed countries.

However, the study also has some limitations. In particular, the TAR model used may not fully capture short-term economic shocks or sudden migration waves. Additionally, since the analysis was limited to G8 countries, the results may not be directly generalizable to developing countries. Future studies could apply similar models in developing countries and examine the effects of migration dynamics on the aging process from a broader perspective. In conclusion, this study demonstrates that the TAR model is a valuable tool for analyzing migration and aging dynamics, providing important insights for determining optimal migration levels in developed countries. These findings offer practical guidance for policymakers in the management of migration.

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Appendix

Table A1. Results of the BDS test

Countries	Variables	Old dependency rate					Net migration				
		2	3	4	5	6	2	3	4	5	6
UK	BDS Statistic	0.032981	0.059681	0.080400	0.098588	0.106508	0.020052	0.027925	0.042489	0.051802	0.053861
	Std. Error	0.010797	0.017384	0.020975	0.022154	0.021653	0.008008	0.011105	0.011540	0.010497	0.008837
	z-Statistic	3.054644	3.433163	3.833193	4.450157	4.918769	2.503921	2.514714	3.682043	4.934719	6.095186
	Prob.	0.0023	0.0006	0.0001	0.0000	0.0000	0.0123	0.0119	0.0002	0.0000	0.0000
Russia	BDS Statistic	0.017006	0.033326	0.056123	0.064645	0.065053	0.035536	0.074913	0.091180	0.092549	0.082929
	Std. Error	0.009062	0.014510	0.017407	0.018278	0.017760	0.013769	0.022235	0.026918	0.028532	0.027989
	z-Statistic	1.876546	2.296713	3.224119	3.536700	3.662891	2.580933	3.369182	3.387333	3.243694	2.962867
	Prob.	0.0606	0.0216	0.0013	0.0004	0.0002	0.0099	0.0008	0.0007	0.0012	0.0030
Japan	BDS Statistic	0.050114	0.062753	0.074863	0.095800	0.087018	0.096640	0.128545	0.118526	0.110370	0.099903
	Std. Error	0.014333	0.023059	0.027814	0.029375	0.028714	0.010976	0.012955	0.011474	0.008901	0.006393
	z-Statistic	3.496499	2.721402	2.691546	3.261240	3.030569	8.804295	9.922153	10.33031	12.39979	15.62675
	Prob.	0.0005	0.0065	0.0071	0.0011	0.0024	0.0000	0.0000	0.0000	0.0000	0.0000
Italy	BDS Statistic	0.027716	0.031645	0.029183	0.021517	0.014666	0.032570	0.085294	0.106163	0.103773	0.098661
	Std. Error	0.010700	0.011346	0.009033	0.006302	0.004071	0.018936	0.030722	0.037391	0.039858	0.039332
	z-Statistic	2.590234	2.789044	3.230643	3.414466	3.602261	1.719949	2.776307	2.839250	2.603599	2.508447
	Prob.	0.0096	0.0053	0.0012	0.0006	0.0003	0.0854	0.0055	0.0045	0.0092	0.0121
France	BDS Statistic	0.025792	0.042347	0.053519	0.068059	0.071767	0.008499	0.009905	0.005351	0.002504	0.000524
	Std. Error	0.012908	0.020715	0.024920	0.026246	0.025582	0.002699	0.001341	0.000500	0.000164	4.95E-05
	z-Statistic	1.998120	2.044268	2.147672	2.593153	2.805399	3.148592	7.388779	10.69930	15.31019	10.56980
	Prob.	0.0457	0.0409	0.0317	0.0095	0.0050	0.0016	0.0000	0.0000	0.0000	0.0000

Countries	Variables	Old dependency rate					Net migration				
		2	3	4	5	6	2	3	4	5	6
Canada	BDS Statistic	-0.004407	-0.003191	-0.000663	-0.000126	-2.07E-05	0.060274	0.103096	0.096469	0.117932	0.092660
	Std. Error	0.001565	0.000621	0.000185	4.84E-05	1.17E-05	0.013518	0.021795	0.026343	0.027877	0.027302
	z-Statistic	-2815.188	-5134.726	-3576.919	-2602.318	-1770.457	4.458916	4.730296	3.662054	4.230433	3.393848
	Prob.	0.0049	0.0000	0.0003	0.0093	0.0767	0.0000	0.0000	0.0003	0.0000	0.0007
Germany	BDS Statistic	0.030437	0.050861	0.074030	0.081359	0.080986	-0.032258	-0.032787	-0.033333	-0.033898	-0.034483
	Std. Error	0.012378	0.019980	0.024173	0.025604	0.025098	0.003720	0.008136	0.013323	0.019088	0.025301
	z-Statistic	2.459007	2.545624	3.062503	3.177567	3.226797	13.67117	13.80694	13.48055	13.30415	13.63109
	Prob.	0.0139	0.0109	0.0022	0.0015	0.0013	0.0000	0.0001	0.0123	0.0757	0.1729