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Feeding the Aging World:
The Role of Demographics in Shaping the Global Food Trade*

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Abstract

The global demographic shift to an ageing society poses challenges for the international food trade. People in different age groups have different dietary preferences, nutritional needs, and income levels, which influence consumer preference and purchasing power. This study examines the impact of global demographic shifts towards silver economies on international food imports using structural gravity analysis. The findings suggest that silver economies will shift consumer preferences to import healthier food, resulting in increased income elasticity of demand for these imports. The primary target markets for healthy food trade are developed countries, particularly Japan, the EU, and the US, where income elasticity is high and remains near or greater than one. Although consumers in developing countries may not prefer healthy foods, their income elasticity for healthy food imports will rise as the elderly population grows.

Keywords: food trade, healthy food, demographic shifts, aging economies

JEL: F10, F14, J10, Q18

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1. Introduction

The global population is expected to increase over the next several decades with demographic shifts towards 'silver economies', as people live longer lives and fertility rates fell. The UN predicts that elderly people will outnumber younger people by the 2060s.[1] As the global economy becomes more crowded with the elderly, consumption patterns for a wide range of products are likely to shift (Kearney, 2010). Aside from a potential increase in demand for the healthcare industry, the food sector will be among the first to be impacted. Various food options may also be promoted as a viable alternative for the elderly in order to foster a healthier lifestyle (Kearney, 2010; Helldan *et al.*, 2012).

Age-related health issues pose a challenge in an ageing world. Noncommunicable diseases (NCDs), malnutrition, overweight, and obesity have all seen an increase in recent years (WHO, 2021; 2022; 2023; Giuntella *et al.*, 2020). These have a negative impact on quality of life and put an economic burden on both the healthcare system and the individual. If consumers are becoming more aware of the impact of food on their health, they may turn to food to treat or prevent health problems. The World Health Organization (WHO) recently released a healthy diet list and practical advice to help people protect themselves from malnutrition in all forms, as well as NCDs such as diabetes, heart disease, stroke, and cancer. (WHO, 2020).

The emergence of silver economies has implications for the dynamics of food trade via a change in importer preference. The overall impact on food trade remains unresolved as the elderly may not consume a greater quantity of nutritious food due to physiological limitations (such as difficulty chewing or swallowing) and economic constraints (Bostic and McClain, 2017; Assad-Bustillos *et al.*, 2019; Mann *et al.*, 2013; Conklin, *et al.*, 2013; Penne and Goedemé, 2021). Conversely, they may also have a desire to purchase more healthy food to maintain their well-being to prevent any age-related diseases (Monsivais *et al.*, 2014; Chung, *et al.*, 2007; Helldan, *et al.*, 2012; Thompson *et al* ., 2011; Vesnaver *et al.*, 2012; Bishop *et al.*, 2020; Shatenstein *et al.*, 2013; 2016).

To the best of our knowledge, this paper is the first to investigate the potential impact of demographic changes on the food trade, with a focus on healthy food products and importer preferences. It contributes to the existing literature on the global food trade by revealing how the megatrend of ageing economies could impact (healthy) food trade through changes in import income elasticity. The structural gravity modelling framework is used to estimate importing countries' age-related income elasticity, which serves as a measure of importer preference across food product categories and destinations. The targeted food products and destination markets are highlighted, presenting both a challenge and an opportunity for food manufacturers and exporters to gain advantages from trade. This study sheds light on how government policy can help the food industry adapt its strategy for the upcoming silver economy.

[1] The data are available on the website: https://population.un.org/wpp/

The paper is organized as follows. Section 2 examines the demographic transition and food trade, focusing on observed trends and patterns as well as the potential impact on food trade from the expansion of silver societies. Section 3 presents the model specification. Section 4 describes the data sources and econometric issues. The findings are presented and analyzed in Section 5. The paper concludes with a summary of key findings and policy implications.

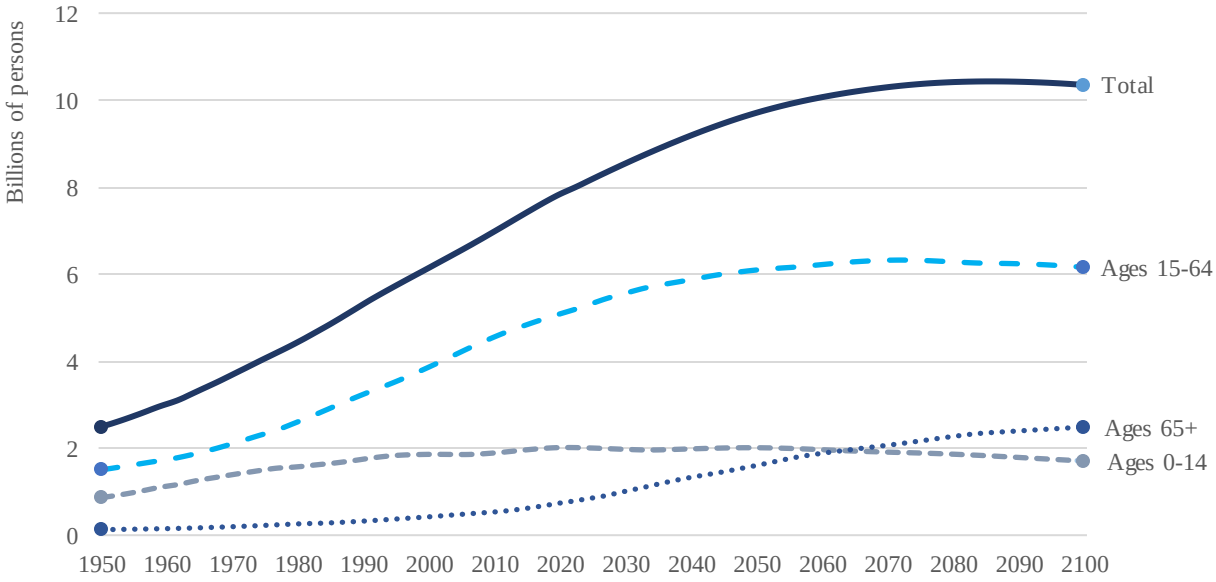
2. Demographic Shifts and Food Trade

2.1 Demographic Shifts and Trends

During the post-second World War period until about the 2000s, world population was growing rapidly with an increase in all age groups, particularly a sharp increase in the working-age population (Figure 1). Nowadays, the world's total population is increasing, but at a slower rate, with the young population declining and the elderly population rapidly increasing. The United Nations predicted that the global population would continue to rise for several decades. The elderly population will have grown dramatically, while birth rates will have gradually declined. In the 2060s, the elderly population will outnumber the youth. In other words, the world's economy is aging.

According to the UN's population projections, both developed and developing countries will face demographic shifts toward aging economies in the next three decades (Figure 2). Despite the fact that both groups of countries have low birth rates, resulting in a gradual decline in the young-age population, the population structures of both groups of countries are distinct. The developed nations are rapidly aging as the elderly population increases and the working-age population decreases. The dependence of the elderly is growing. In contrast to developed countries, an increase in the elderly population coincides with an increase in the working-age population. Developing countries are turning into aging societies at a slower rate than developed countries.

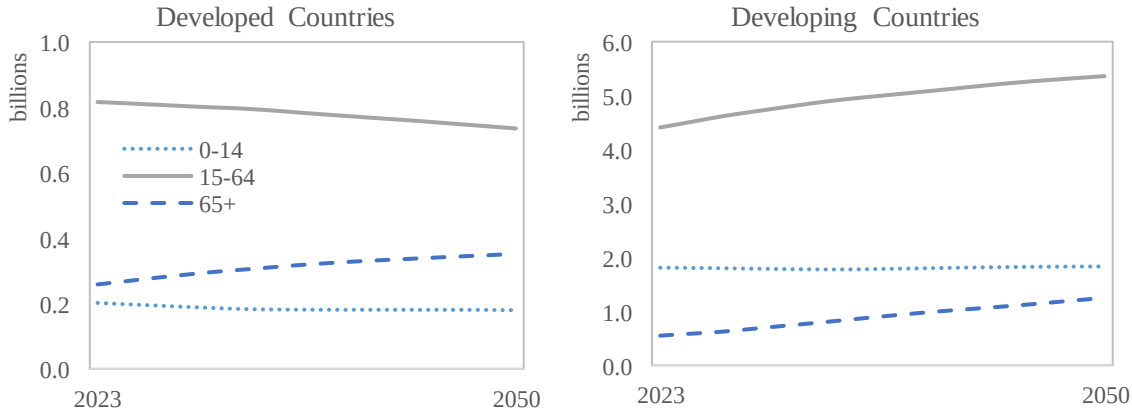
Figure 1. Total World population and population by broad age groups, 1950-2100



Note: The medium projection from 2022 to 2100

Source: Authors' calculation using the data from the United Nations, Department of Economic and Social Affairs, Population Division, World Population Prospects 2022.

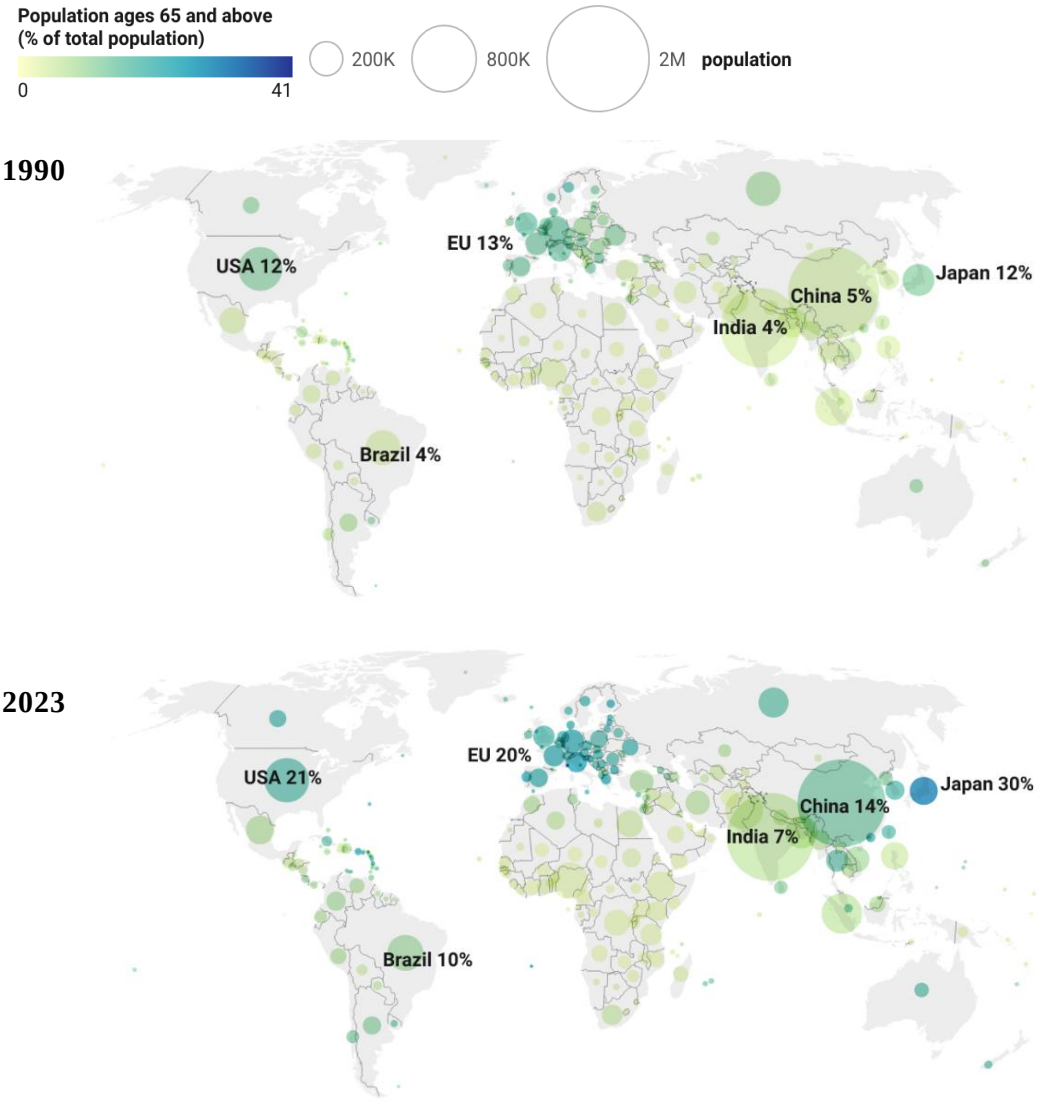
Figure 2. Demographic shifts by country groups, 2023-2050



Source: Authors' calculation using the data from the United Nations, DESA, Population Division, World Population Prospects 2022.

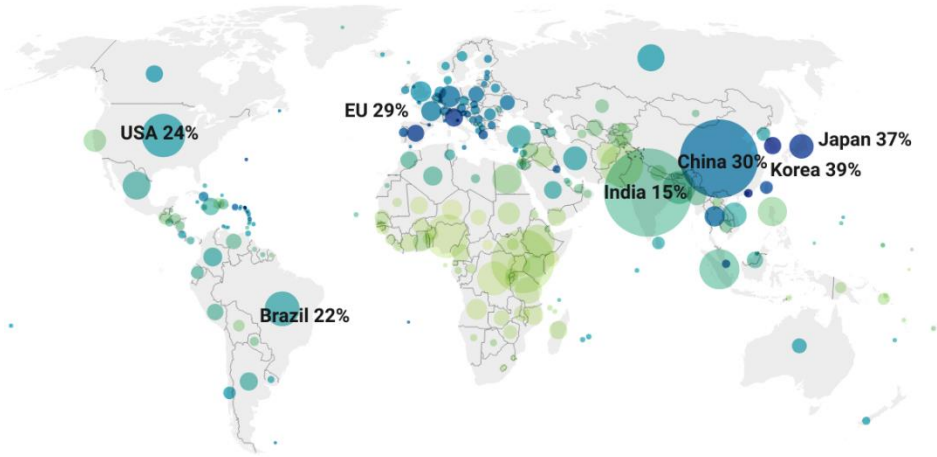
Regarding an increase in the elderly population, countries with a large proportion of the elderly can be divided into three categories: aging, aged, and super-aged.[2] Figure 3 depicts the demographic transition to a super-aged society. Japan experienced the first major shift and is now a super aged society, with the elderly accounting for 30 percent of the population in 2023. With recorded old-age populations, the United States and many of the European Union will follow soon. South Korea, along with China, will be the next in line by 2050.

Figure 3. Demographic shifts by countries, 1990 vs. 2023 vs. 2050



[2] An "aging society" is defined as one in which 7–14 percent of the population is 65 or older. In an "aged society" and a "super-aged society," those 65 and older make up 15 to 20 percent of the population, and more than 21 percent, respectively.

2050



Source: Authors' calculation using the data from the United Nations, DESA, Population Division, World Population Prospects 2022.

2.2 Food Trade Patterns

Table 1 shows that developed nations have an important role in global food exports. The majority of these food items are in processed form[3], a category that has shown a significant growth over the previous few decades (Athukorala and Sen, 1998; Jongwanich, 2009; Suanin, 2021; 2023). The United States and European countries were the top food exporters. Over the past two decades, there has been a progressive expansion in the importance of emerging countries, particularly those in East Asia and South America, as exporters.

Concerning destination markets, the primary source of food import demand has been predominantly from developed countries. The bulk of participants came from European countries and the G7 countries, especially the US (Table 1). Nevertheless, the significance of the demand from developing countries, especially developing Asia, has been steadily growing.

[3] The United States Federal Food, Drug, and Cosmetic Act, Section 201, Chapter II, defines processed food as 'any food other than a raw agricultural commodity and includes any raw agricultural commodity that has been subject to processing, such as canning, cooking, freezing, dehydration, or milling'.

Table 1. Shares of destination markets and exporting countries in world food trade (percent)

	Destination markets		Exporting countries	
	2000-2002	2020-2022	2000-2002	2020-2022
Developed countries	**78.94**	**58.01**	**67.19**	**56.21**
Northern America	15.69	14.56	16.31	13.22
Developed Asia and the Pacific	12.52	5.69	5.10	4.60
Europe	50.73	37.76	45.78	38.39
Major developed economies (G7)[a]	53.80	33.48	37.56	28.54
Developing countries	**18.90**	**38.50**	**30.81**	**39.38**
Africa	1.10	3.90	3.36	3.49
East Africa		0.51	0.52	0.57
West Africa		0.89	0.98	1.11
North Africa	0.82	1.70	0.71	0.92
Central Africa			0.12	0.08
Southern Africa	0.28	0.80	1.03	0.81
Asia	12.64	29.45	14.90	18.24
East Asia	11.39	24.32	12.17	14.00
South Asia	0.88	2.92	1.69	2.50
Western Asia	0.37	2.21	1.04	1.74
Latin America and the Caribbean	5.16	5.14	12.55	17.65
Caribbean		0.01	0.36	0.07
Mexico and Central America	2.67	2.24	3.64	4.57
South America	2.49	2.90	8.55	13.01
Transition Economies	**2.16**	**3.49**	**2.00**	**4.41**

Note: a\ the G7 countries consist of Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States.

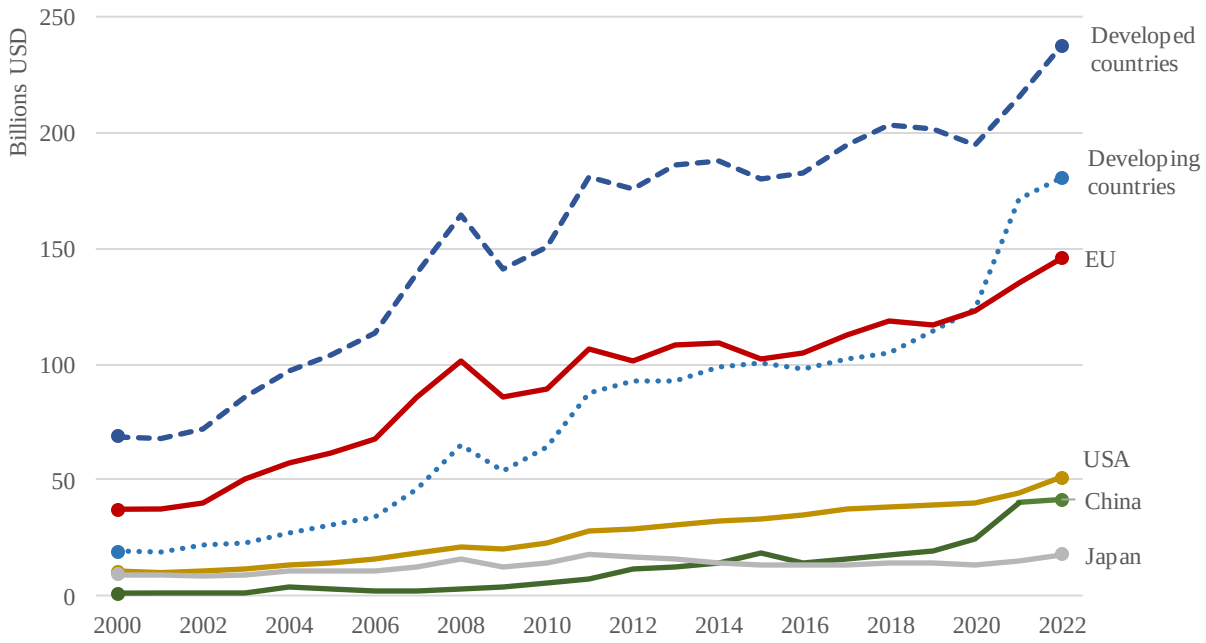
Source: Authors' calculation using the data from S&P Global Market Intelligence

There has been a noticeable increase in the consumption of healthy foods in recent decades (Wunsch, 2022; 2023). Based on healthy diet recommendations in WHO (2020), we define healthy food goods at HS 6-digit levels and show their import trend in Figure 4.[4] Possible factors contributing to growth and demand for healthy food include a worldwide pandemic and a persistent focus on non-communicable diseases (NCDs), malnutrition, diabetes, overweight, and obesity (WHO, 2021; 2022; 2023; Giuntella *et al.*, 2020). The need for

[4] See Section 5 for additional information on healthy food data, and Appendix Table A1 for a list of healthy food products.

healthy foods has grown substantially in recent decades. Most of the demand originates from developed countries, with demand from developing countries also exhibiting an upward trajectory, particularly experiencing a significant surge since the onset of the COVID-19 pandemic. The United States, China, Japan, and several European countries are the primary sources of these demands.

Figure 4. Destination markets of healthy food exports (billions USD), 2000-2022



Source: Authors' calculation using the data from S&P Global Market Intelligence

2.3 From Demographics to Food Trade

Changes in population demography can have the potential impact on import demand and global food trade pattern. That is, an increase in population corresponds to an increase in food demand. This spike may increase the number of imported food goods, particularly in countries whose domestic production falls short of meeting the needs of their growing populations. In contrast, countries dealing with a declining population may experience a decline in their appetite for food imports. Furthermore, changes in demographics, such as changes in age distribution, might influence customer preferences for certain types of food. For example, an expanding elderly population may result in a greater desire for health-conscious or medicinal foods, altering food trade patterns.

Even if nutrition has proven as a key factor for healthier lifestyle and longer living, the evidence on healthy food consumption pattern of the old are mixed (Caso and Vecchio, 2022). The old do not consume healthy food as much as they otherwise would do due to their physiology and economic conditions. Some have

difficulty in meal preparation, swallowing (Bostic and McClain, 2017) as well as chewing (Assad-Bustillos *et al.*, 2019; Mann *et al.*, 2013). The loneliness from loss of partner or being apart from family reduces the old's appetite (de Boer *et al.*, 2013; Smith and Miller, 2011). For economic factors, after retirement, the old have lower level of income and cannot purchase healthier diet (Conklin, *et al.*, 2013; Penne and Goedemé, 2021).

On the other hand, the old adults consume more of healthy food because they have more free time to cook themselves healthier food after their retirement (Monsivais *et al.*, 2014; Chung, *et al.*, 2007; Helldan, *et al.*, 2012). The elder with financial adequacy (Thompson *et al.*, 2011; Vesnaver *et al.*, 2012) and higher education (Bishop *et al.*, 2020; Shatenstein *et al.*, 2013; 2016) choose better diet. Also, region plays a vital role in healthy food consumption since living in wealthier or more developed areas have more access to variety of healthy food choices (Granic *et al.*, 2015). If the hypothesis that the old demand for healthier food is true, the escalated trade flow is expected.

3. Model Specification

Tinbergen (1962) first introduced the gravity model as an observed phenomenon. Subsequently, Anderson and Van Wincoop (2003) and Baier and Bergstrand (2010) established its theoretical basis. According to the existing literature on gravity, the gravity model can be described as the following system:

$$X_{ijt} = \frac{Y_{it}E_{jt}}{Y_t}\left(\frac{\tau_{ijt}}{\pi_{it}P_{jt}}\right)^{1-\sigma} , \quad (1)$$

$$\pi_{it}^{1-\sigma} = \sum_j \left(\frac{\tau_{ijt}}{P_{jt}}\right)^{1-\sigma} \frac{E_{jt}}{Y_t} , \quad (2)$$

$$P_{jt}^{1-\sigma} = \sum_i \left(\frac{\tau_{ijt}}{\pi_{it}}\right)^{1-\sigma} \frac{Y_{it}}{Y_t} , \quad (3)$$

The gravity equation is showed in equation (1). Bilateral trade flow (X_{ijt}) from country *i* to country *j* are primarily driven by two main components:

(i) *Size factors*: economic size is expressed as the product of the exporter's total output (Y_{it}) and the importer's total expenditure (E_{jt}), divided by total world output (Y_t). That is, the larger a country's production scale, the more exports it can sell to any trading partner. Similarly, larger countries (in terms of expenditure or income) have a better opportunity to import a broader range of products from all exporting countries. As a result, these size-related variables are positively correlated with bilateral trade flows.

(ii) *Trade cost factors*: these include both the direct trade costs between the two countries (τ_{ijt}) as well as outward and inward multilateral resistance terms (MR terms: π_{it} and P_{jt}). These MR terms, as defined in

equations (2) and (3), shed light on the relative nature of bilateral trade costs in relation to the countries' average costs when dealing with other trading partners. Also, the trade cost term is elevated to the elasticity of substitution (σ), determining the extent to which trade flows respond to variations in trade costs.

In the empirical bilateral trade analysis, the size factor coefficients are not restricted as a unit. Instead, the coefficients can absorb the effects of demographic factors on bilateral trade in a flexible manner. We extend the gravity model to account for the potential effects of demographic changes on food demand via the importer's size factor. The nonlinear equation for three-dimensional panel analysis is as follows:

$$X_{ijt} = exp\left\{\alpha_0 + \beta_1(\log E_{jt} * BOD_{ij}) + \beta_2(\log E_{jt} * BOD_{ij} * AGED_{jt}) + \alpha_1 PTA_{ijt} + \alpha_{2t} INT_{ijt} + \theta_{ij} + \theta_{it} + \theta_{jt}\right\} u_{i,j,t} \quad (4)$$

where X denotes bilateral trade.

AGED is population ages 65 and above (% of total population)

E is the total expenditure (income) of importing countries.

BOD is a time-invariant binary variable, with the value 1 if the source and destination countries of a trade flow are distinct ($i \neq j$) and the value 0 if they are the same ($i=j$).

PTA is a time-varying policy variable taking the value 1 if a country-pair joining the same preferential trade agreements.

The model includes all three sets of fixed effect terms (FEs). θ_{ij} is a country-pair fixed effect that captures any bilateral trade cost between countries while also accounting for potential endogeneity due to the reverse causality of the trade policy variable, *PTA*. The remaining fixed effects are country-specific, including *exporter-time* fixed effects (θ_{it}) and *importer-time* fixed effect (θ_{jt}). These two fixed effects account for MR impacts.[5] u_{ijpt} is the error term. The subscriptions i, j, p, and t represent exporting countries, importing countries, product group, and time, respectively.

[5] Previous literature has used *importer-time* and *exporter-time* FEs as proxies for multilateral resistances due to their ability to absorb both observable and unobservable country-specific impacts (Baldwin and Taglioni, 2007; Ferro *et al*., 2015; Shepherd, 2013; Crivelli and Gröschl, 2016). However, using fixed effects precludes us from investigating the effects of time-varying independent variables associated with exporting or importing countries.

Yotov *et al*. (2016) and Yotov (2022) recommended that the dependent variables (*X*) should encompass both international and intranational observations for theoretical consistency. The binary variable *BOD* distinguishes the two types of data.

Since the variable *E* is a time-varying country specific variable, its impact on bilateral trade is subsumed in the *importer-time* FEs. To determine the impact on international food trade, we must multiply *E* by *BOD*. Given the budget constraint that total expenditure equal to income, the larger the value of *E*, the higher the income and purchasing power of food imports. The coefficients β_1 represent the importing country's income elasticity on food trade. If that kind of food is treated as a normal product, we expect the positive coefficient.[6] If the coefficient is greater than one, we expect that kind of food as a luxury items that consumers purchase proportionally more of in relation to a percentage change in their income.

The variable of our interest is the interaction term between *E* and *AGED*. The coefficient β_2 indicate the trade effect of a rise in the income of importing countries, which are transitioning to more aging economies (age-related income elasticity). Therefore, if *E* and its interaction term is statistically significant on trade, the total income elasticity would be $\beta_1 + \beta_2 AGED$, depending on the level of aged population share of the importing countries.

The trade effects of age-related income are inconclusive. As the population ages, income elasticity may decline. When compared to younger people, older adults consume smaller portions and have lower calorie needs.[7] Additionally, a shift in consumer preferences as individuals age may cause certain types of food to become substandard products. As income increases, this can lead to a decrease in imported food consumption. On the other hand, as the population ages, income elasticity may increase. Elderly people may have more disposable income than younger people.[8] This could result in increased purchasing power (the income effect), allowing them to purchase more imported foods. Older people might acquire new dietary preferences, like a desire for specialized or health-conscious foods. These preferences may cause an increase or decrease in demand for specific imported foods. Based on these potential outcomes, we decide to estimate the gravity model for various product types (food, healthy food, and certain food categories) and destination market groups (world, developed countries, and developing countries).

All bilateral time-invariant control variables are measured in the fixed effect terms. The model includes two time-varying control variables. The first one is the trade policy variable, *PTA*. If two countries sign the same trade agreement, the agreement has the potential to facilitate their bilateral trade flows. However, the actual trade impact depends on Rules of Origins (RoOs) and other administrative complications. As a result, the

[6] Normal goods with an income elasticity of demand between zero and one are commonly referred to as necessity goods, which are products and services that consumers will purchase regardless of their income level.
[7] Alice Callaha. (2023). How Do My Calorie Needs Change as I Age?. *The New York Times*. October. 10, 2023.
[8] Charles Wallace. (2024). Aging Populations Transform Economies. *Global Finance*, Economics, Policy & Regulation. March 7, 2024.

sign of the *PTA* coefficient is ambiguously determined. The second one is a time-varying border dummy variable (*INT*), which is the product of a time dummy and *BOD*. According to Bergstrand *et al*. (2015), this *INT* captures all bilateral factors influencing international relative to intranational trade on average over time relative to the base period, including common globalization effects.

4. Data Sources and Econometric Issues

The trade equation is estimated using a four-dimensional panel dataset (*importer-exporter-product-time*) of food trade from 2000 to 2022. It covers 168 exporting countries with 105 trading partners. Based on the United Nations country classification, these countries can be divided into developing and developed country groups.[9]

Data on food trade are derived from the import data based on the Harmonized System Code (HS Code) at the 2-digit level, which includes 18 chapters.[10] In addition, we adhere to the definition of healthy diets proposed by WHO (2020). The healthy food products are identified at the 6-digit level based on the HS code and then aggregated to the 2-digit level[11], which can be broadly categorized into 6 groups, including (i) foods from animal sources, (ii) fruits and vegetables, (iii) beans and whole grains, (iv) Oils, (v) beverages, and (vi) non-sweet food products.

The income of importing countries (E) is measured as Gross Domestic Product (GDP), which is not adjusted for inflation, aligning with the methodologies of Yotov et al. (2016) and Head and Mayer (2014).

The data are gathered from a variety of sources.[12] The trade data come from the S&P global market intelligence database. The Gross Domestic Product (GDP) and the population data across countries were collected from the World Bank database. The data on preferential trade agreements were retrieved from the Asia Regional Integration Center, organized by the Asian Development Bank (ADB).

The presence of zero trade flows presents a significant challenge when estimating the gravity model. Because information from zero-trade data is excluded, the widely used Ordinary Least Squares (OLS) method produces biased and unreliable estimates (Santos Silva and Tenreyro, 2006; 2011). In order to effectively account for the presence of zero trade flows data (nearly 62 percent of total trade data), the trade equation is estimated using a multiplicative form, as shown in equation (4).

As the trade equation's parameters are non-linear and zero trade is included, this study uses the Poisson pseudo-maximum likelihood (PPML) method developed by Santos Silva and Tenreyro (2006;

[9] The list of developed and developing countries based on the U.N. country classification (2023 edition): https://www.un.org/development/desa/dpad/publication/world-economic-situation-and-prospects-2023/
[10] Chapters 02, 03, 04, 07, 08, 09, 10, 11, 12, 13, 15, 16, 17, 18, 19, 20, 21, 22
[11] See Appendix Table A1 for the list of healthy food products.
[12] The data statistics are reported in Table A2, Appendix.

2011). The PPML has the advantage of providing estimates that are both consistent and unbiased, resistant to various types of heteroscedasticity, and effective even when a significant proportion of trade flows are zero (Yotov *et al.*, 2016; Shepherd, 2013; Crivelli and Gröschl, 2016; Head and Mayer, 2014).

5. Results

The estimated gravity equations are reported in Table 2. The estimates for the entire sample (column 1) show that the coefficient of *E*BOD*AGED* is positive and statistically significant at the 0.01 significance level. That is, the food trade effect of importing countries' income is positively dependent on their share of the elderly population. More specifically, given that the world's aged population is currently around 10 percent, the income elasticity of global food imports is about 0.04.[13] This indicates that food imports increase with income, but not as fast as income does, which is consistent with Engle's law, and the estimates of Suanin (2023).[14] However, this finding is not consistent with the findings in previous studies of processed food and other agricultural products, which are around two (e.g., Islam and Subramanian, 1989; Baiardi *et al.*, 2015; Suanin, 2021).

The estimated impact of demographic changes on trade for specific destination markets is shown in Table 2 columns (2) to (4). The estimates of the interaction term *E*BOD*AGED* are statistically significant at the small conventional significance levels for all destination market groups. This is consistent with the prior result of the entire sample, confirming that income elasticity (or consumer preference) for food import has changed, depending on the elderly population. Unlike developing countries markets, the results for developed countries markets show that *E*BOD* is also significant at the 0.01 significance level, with a coefficient magnitude greater than one.

The gravity equation for healthy food trade is presented in Table 3. Overall, the trade effect of income related to aged population share (*E*BOD*AGED*) is statistically significant, but it is slightly larger than that of the food trade (Table 2). As the world's elderly population currently accounts for 10 percent of the total global population, the income elasticity of healthy food imports is approximately 0.1 on average.

[13] The total income elasticity should be calculated from $\beta_1 + \beta_2 AGED$. However, in the case that β_1 is insignificant from zero, the income elasticity is equal to $\beta_2 AGED$.
[14] The Engle's law suggests that as an increase of income, the expenditure share of food decline though the total amount of expenditure rise.

Table 2. The age distribution effect on food trade classified by destination markets

Destination markets:	**World**	**Developed countries**	**Developing countries**
	(1)	(2)	(3)
Log *E*BOD*	-0.04	1.49***	-0.57
	(0.07)	(0.20)	(0.36)
Log *E*BOD*AGED*	0.004***	0.01***	0.01*
	(0.001)	(0.002)	(0.004)
PTA	0.04***	0.03***	0.06*
	(0.004)	(0.005)	(0.03)
constant	20.60***	-27.39***	34.67***
	(2.23)	(6.53)	(9.36)
INT	yes	yes	yes
Country-pair FEs	yes	yes	yes
Exporter-time FEs	yes	yes	yes
Importer-time FEs	yes	yes	yes
Pseudo R^2	0.99	0.99	0.99
No. of Obs.	405,720	131,376	227,976

Note: ***, **, and * are statistically significant at 0.01, 0.05 and 0.1 levels, respectively.

Considering specific destination markets, the trade effect of income related to the aged population is significant and positive, as shown in Table 3 columns (2) and (3). These findings indicate that the demand for healthy food imports increases when importing countries become richer and have aging economies. However, the direct income effect on healthy food trade varies across markets. The results show that the impact of *E*BOD* is significant and positive for markets in developed countries. In contrast to developed countries markets, the trade effect of *E*BOD* is significant and has a negative sign. The results reflect that consumers in developing countries do not prefer healthy food products.

We estimated the income elasticities (IEs) of healthy food imports across market groups using the United Nations' predicted aged population data and the estimates in Table 3. Figure 5 depicts the estimated income elasticities for healthy food imports in 2023 and 2033. The size of the bubble graph indicates countries' healthy food imports in 2022, reflecting their relative importance in the global market. We discovered that the estimated income elasticity can be classified into two groups: positive and negative IEs.

Table 3. The age distribution effect on healthy food trade classified by destination markets

Destination markets:	**World**	**Developed countries**	**Developing countries**
	(1)	(2)	(3)
Log *E*BOD*	-0.50	0.52***	-1.24***
	(0.40)	(0.15)	(0.48)
Log *E*BOD*AGED*	0.01*	0.02***	0.01***
	(0.003)	(0.002)	(0.004)
PTA	0.03*	0.01***	0.10**
	(0.02)	(0.006)	(0.05)
constant	31.08***	-4.50	51.58***
	(10.90)	(5.33)	(12.69)
INT	yes	yes	yes
Country-pair FEs	yes	yes	yes
Exporter-time FEs	yes	yes	yes
Importer-time FEs	yes	yes	yes
Pseudo R^2	0.98	0.99	0.97
No. of Obs.	405,720	131,376	227,976

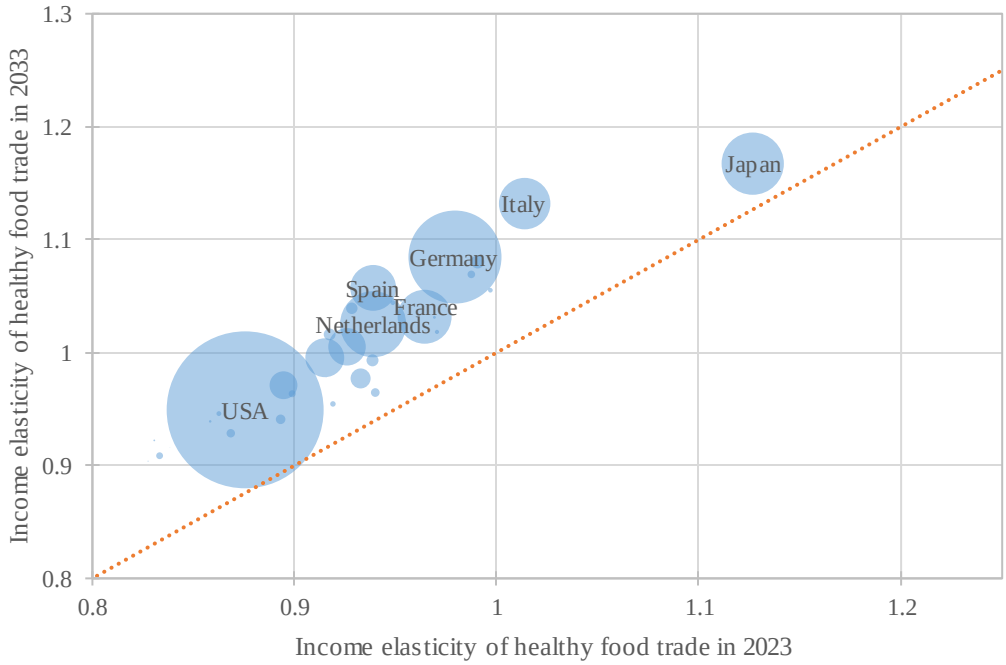
Note: ***, **, and * are statistically significant at 0.01, 0.05 and 0.1 levels, respectively.

Figure 5a shows that developed countries are the target destination markets, with high income elasticities even a decade later. In particular, Japan and Italy have high income elasticities (>1) both now and a decade later. Several other developed countries, including Finland, Portugal, Greece, Germany, Bulgaria, Latvia, France, Slovenia, and Lithuania, have income elasticity less than one but expect it to increase over the next decade. In addition, the US, the largest importer in this group, would have an income elasticity of 0.95 in 2033.

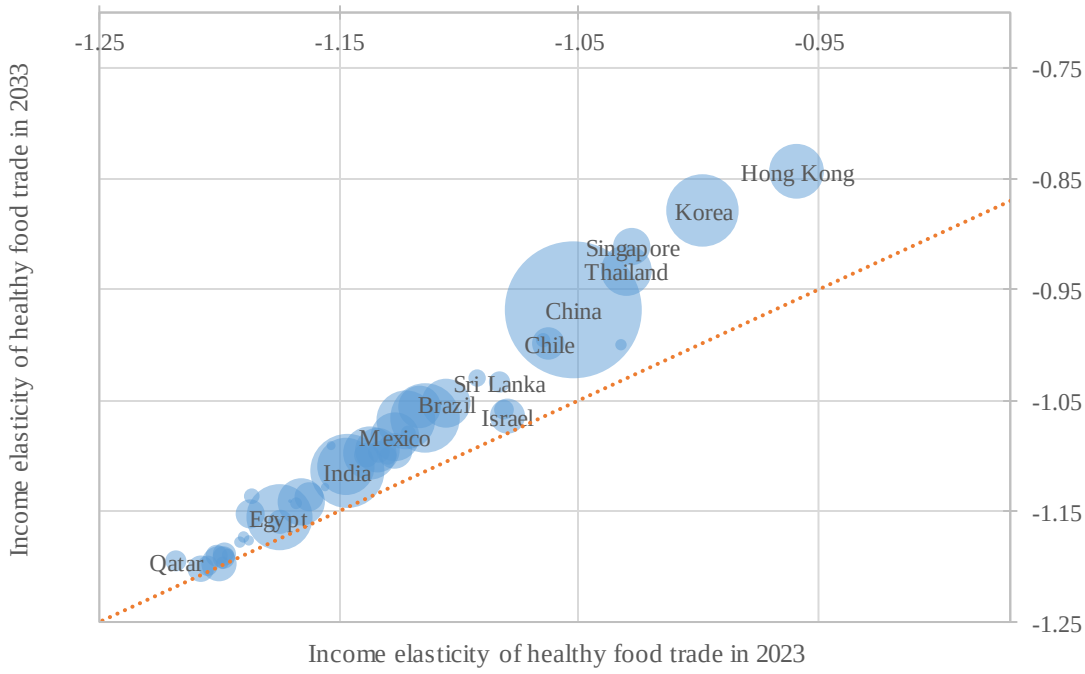
Figure 5b depicts negative estimated IEs in developing country markets. The center of all bubbles is above the 45-degree line. That is, while the income elasticity of healthy food imports is currently negative, it will rise over the next decade as the proportion of the elderly population grows (except Zimbabwe), particularly in Hong Kong, Korea, Singapore, Thailand, and China (the largest importer in this group).

Figure 5. Income elasticity of healthy food imports to selected markets in 2023 vs 2033

5a. Positive income elasticity



5b. Negative income elasticity



Note: The bubble size is the import value in 2022; the dot line represents the 45-degree line.

Table 4 shows the estimates for six categories of healthy food imports. We discovered that the income effect is mostly significant and positive in the healthy food trade, including fruits and vegetables, animal-based products, oils, and non-sweet products. The findings also show that the income elasticities of these products vary by aged population share. The coefficients of *E*BOD* AGED* are particularly high for animal-based products, oils, and non-sweet products. However, there is no evidence that income or age distribution influence consumer preference for healthy grain and beverage imports.

Table 4. The age distribution effect on healthy food trade classified by product categories

Product categories:	(1) Fruit & Veg.	(2) Grain	(3) Animal	(4) Oil	(5) Bev.	(6) Non-sweet
Log *E*BOD*	0.39***	0.04	0.44***	0.80***	-0.63	0.28***
	(0.09)	(0.06	(0.04)	(0.15)	(0.52)	(0.02)
Log *E*BOD* AGED*	0.002***	0.0002	0.01***	0.02***	-0.004	0.01***
	(0.001)	(0.004)	(0.002)	(0.0003)	(0.005)	(0.002)
PTA	0.03***	-0.002	0.02***	0.09***	0.03	-0.001
	(0.005)	(0.004)	(0.005)	(0.03)	(0.02)	(0.003)
constant	7.95***	19.16***	2.85	-7.96*	39.25***	7.77***
	(2.26)	(1.88)	(2.03)	(4.41)	(14.01)	(1.14)
INT	yes	yes	yes	yes	yes	yes
Country-pair FEs	yes	yes	yes	yes	yes	yes
Exporter-product-time FEs	yes	yes	yes	yes	yes	yes
Importer-product-time FEs	yes	yes	yes	yes	yes	yes
Pseudo R^2	0.99	0.98	0.99	0.97	0.99	0.98
No. of Obs.	405,720	405,720	405,720	405,720	405,720	405,720

Note: The standard errors are shown in parentheses; *** and ** are statistically significant at 0.01, 0.05 and 0.1 levels, respectively.

6. Conclusion and Policy implications

The global megatrend of demographic change towards an aging society poses a challenge to international food trade. Individuals of varying ages have distinct dietary preferences and specific nutritional needs, in addition to disparate purchasing capabilities influenced by their income levels. Hence, changes in the age distribution of a

population can potentially influence the pattern of food trade. This study uses structural gravity analysis to investigate the impact of global demographic change towards silver economies on international food imports, focusing on income elasticities for food imports across developed and developing countries markets and across categories of healthy food products.

According to our estimates, the emergence of silver economies has positively impacted food trade through a shift in consumer preference as measured by income elasticity. However, the impact is rather modest. The United Nations projects that the proportion of the global elderly population will reach approximately 13 percent within the coming decade. As a result, the average income elasticity of global food trade would be approximately 0.05.

Three key findings are relevant to the healthy food trade. First, as the global elderly population grows, the income elasticity of healthy food imports increases. Furthermore, the income elasticity of healthy food imports is greater than that of other food types that the WHO does not consider to be healthy. More specifically, economic growth in silver economies will increase import demand for healthy products like fruits and vegetables, animal-based foods, and non-sweet foods. Second, developed countries are the primary target markets for healthy food trade. The estimated total income elasticity of healthy food imports in developed countries is relatively high and remains nearly or greater than one even a decade later, particularly in Japan, the EU, and the United States (the largest healthy food importers). Third, consumers in developing countries, unlike their counterparts in developed countries, do not exhibit a preference for healthy food items. As their income rises, they tend to opt for alternative food choices rather than healthy ones. However, the income elasticity of healthy food imports in developing countries may rise over several decades as the elderly population grows, particularly in Hong Kong, Korea, Singapore, Thailand, and China (the world's second-largest importer of healthy food).

Based on the findings, we can draw the following implications for food companies and the government in order to provide support for the food sector and food trade. Governments ought to acknowledge the impact of their population changes on the need for imported food and take into account age-related considerations when participating in trade negotiations, especially regarding healthy foods that are preferred among older people. In addition, governmental collaboration can effectively facilitate and improve trade partnerships between countries with an increasing elderly population and countries with a solid capacity to produce food tailored to the preferences of older people.

Furthermore, it is advisable for companies (including governments) to contemplate (and endorse) making investments in the production of healthy food products in order to meet the potential surge in demand for imports due to the global ageing population. These food items may include fruits and vegetables (i.e., plant-based products), animal-based foods (i.e., meat, fish, eggs, and milk), and non-sugary foods. Given that healthy food is typically a product that requires extensive research, both governments and companies may choose to

allocate resources to research and development (R&D) in order to stimulate innovation in the processing of these food items and improve their competitiveness in the healthy food trade.

Exporting countries ought to prioritise expanding their food export markets, specifically targeting markets with high incomes and/or a significant proportion of the elderly population. This presents an opportunity for exporting countries to enter new markets and cater to the evolving preferences of consumers due to the ageing population.

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Appendix

Table A1. List of healthy food products (HS code)

I. Foods from animal sources (meat, fish, eggs and milk)
020311, 020312, 020319, 020321, 020710, 020721, 020722, 020739, 020900, 030211, 030212, 030219, 030221, 030222, 030223, 030229, 030231, 030232, 030233, 030239, 030240, 030250, 030261, 030262, 030263, 030264, 030265, 030266, 030269, 030270, 030310, 030321, 030322, 030329, 030331, 030332, 030333, 030339, 030341, 030342, 030343, 030349, 030350, 030360, 030371, 030372, 030373, 030374, 030375, 030376, 030377, 030378, 030379, 030380, 030410, 030420, 030490, 030510, 030520, 030530, 030541, 030542, 030549, 030551, 030559, 030561, 030562, 030563, 030569, 030611, 040110, 040120, 040130, 040210, 040221, 040291, 040700, 040811, 040819, 040891, 040899
II. Fruit and vegetables and plant-based products
07, 08, 090111, 090112, 090121, 090122, 090210, 090220, 090230, 090240, 090300, 090411, 090412, 090420, 090500, 090610, 090620, 090700, 090810, 090820, 090830, 091010, 091020, 091030, 091040, 091050, 091091, 091099, 180100, 180500, 190490, 200110, 200120, 200190, 200210, 200290, 200310, 200320, 200410, 200490, 200510, 200520, 200530, 200540, 200551, 200559, 200560, 200570, 200580, 200590, 200710, 200819,
III. Beans and whole grains
100110, 100190, 100200, 100300, 100400, 100510, 100590, 100620, 100630, 100640, 100700, 100810, 100820, 100890, 110820, 110900, 120100, 120210, 120220, 121210, 121292,
IV. Oils
150410, 150420, 150710, 150790, 150910, 150990, 151211, 151219, 151410, 151490,
V. Beverages
220110, 220190
VI. Non-sweet food
040110, 040120, 040130, 040221, 040291, 180500, 220110, 220190

Table A2. Data statistics

Variable	Measurement	Unit	Mean	Std. Dev.	Min	Max
X	Import value	Billion USD	0.04	0.43	0	50.50
E	Gross Domestic Product	Billion USD	547.00	1,850.00	0.82	25,500
AGED	Aged population share	Percent	9.49	5.96	0.86	29.92
PTA	Dummy variable of trade agreements	-	0.13	0.34	0	1

Note: 493,920 observations, years 2000-2022, 105 importing countries, and 168 exporting countries.