



# Demographic Shifts and Potential Food Trade Impacts: A case of ASEAN food export

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# **Demographic Shifts and Potential Food Trade Impacts: A case of ASEAN food export**

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## **Abstract**

Despite the declining fertility rates, demographic changes are anticipated to increase the world's population over the next several decades. Due to this shift, elderly people will outnumber younger ones. Because of age-related dietary preferences and food production efficiency, population demographics may have an impact on food trade patterns. The study uses structural gravity analysis to investigate the impact of demographic shifts on ASEAN food exports. The findings indicate that global population growth influences demand for ASEAN food exports. However, import demand is dwindling with age, particularly in developed countries and the European Union (EU). In contrast, the United States and China are prospective markets for ASEAN food exporters. These also apply to healthy food exports. A demographic shift toward an aging population also boosts ASEAN's export capacity.

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Keywords: Food trade, Healthy food, Demographic shifts, ASEAN

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## 1. Introduction

The global population is expected to rise over the next few decades because of demographic shifts, despite falling fertility rates. As a result of this transition, UN estimated that elderly people will outnumber younger ones in 2060s.<sup>2</sup> As the world economy becomes more crowded with the old, consumption patterns on variety of products are likely to be influenced (Kearney, 2010). Apart from a coming surge in demand for healthcare industry, food sector will be among the other first to be affected. Various food options may also be advocated as a viable alternative for the senior population in order to foster the cultivation of a healthy lifestyle (Kearney, 2010; Helldan et al., 2012). This study investigates the potential impact of demographic shifts on the export of food products, with an additional focus on the export of healthy food.

Even if the contribution of developed countries to global food exports is significant, there has been a notable rise in the involvement of developing countries (Suanin, 2021; 2023). Specifically, the proportion of food exports originating from developing countries has climbed from around 30 percent in the 1990s to 40 percent in the 2020s. Moreover, it is worth noting that a major 25 percent of food exports from developing countries can be attributed to the Association of Southeast Asian Nations (ASEAN).

The emergence of silver economies can be attributed to the dynamics of food trade, which can be analyzed through at least two distinct factors. The first issue to consider is the demand side, specifically in relation to consumption patterns. The overall impact on food trade remains unresolved as seniors 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 in order to maintain their well-being (Monsivais and Drewnowski, 2014; Chung, *et al.*, 2007; Helldan, *et al.*, 2016; Thompson *et al.*, 2011; Vesnaver *et al.*, 2012; Bishop *et al.*, 2020; Shatenstein *et al.*, 2016; Shatenstein *et al.*, 2013). The second part is to the impact on the production side. The process of aging can have a multifaceted impact on an individual's level of productivity. Extended periods of employment can result in increased accumulation of human capital, so enhancing productivity (Mincer, 1974; Becker, 1975). Conversely, the physiological state of older individuals may hinder cognitive abilities necessary for specific

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<sup>2</sup> The data are available on the website: <https://population.un.org/wpp/>

occupations, consequently reducing productivity levels (Daveri and Maliranta, 2007; Maurer, 2001; Lallemand and Rycx, 2009; Hayward et al. 1997). Hence, it is imperative to investigate the aforementioned equivocal effect.

To the best of our knowledge, there are no literature exploring food trade effect of the demographic change, especially in the ASEAN context. This paper is the first attempt to shed light on how governments seeking to promote the food industry should redesign their strategy to the approaching silver economies.

The paper is organized as follows. Section 2 describes the trends and patterns of the demographic transition and ASEAN food exports, while section 3 proposes an analytical framework for the potential food trade impact from growing silver societies. Next, the model specification is explained in Section 4. In section 5, we narrate the data sources and econometric issues. Results are reported and discussed in section 6. We then conclude and recommend some policy implications.

## **2. C Demographic Shifts and ASEAN Food Trade**

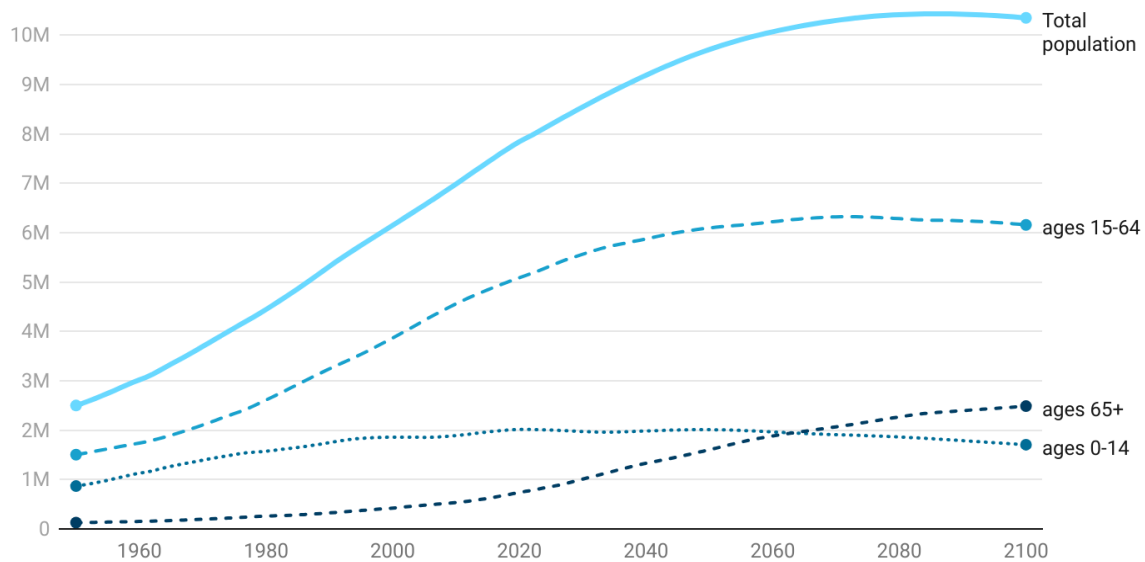
### **2.1 Demographic Shifts and Trends**

Over several decades, the total population has grown significantly. Prior to the 2000s, population growth was primarily explained by 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 for the next three decades (Figure 2), both developed and developing countries will face demographic shifts toward aging economies. 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 population and population by broad age groups (thousands), 1950-2100

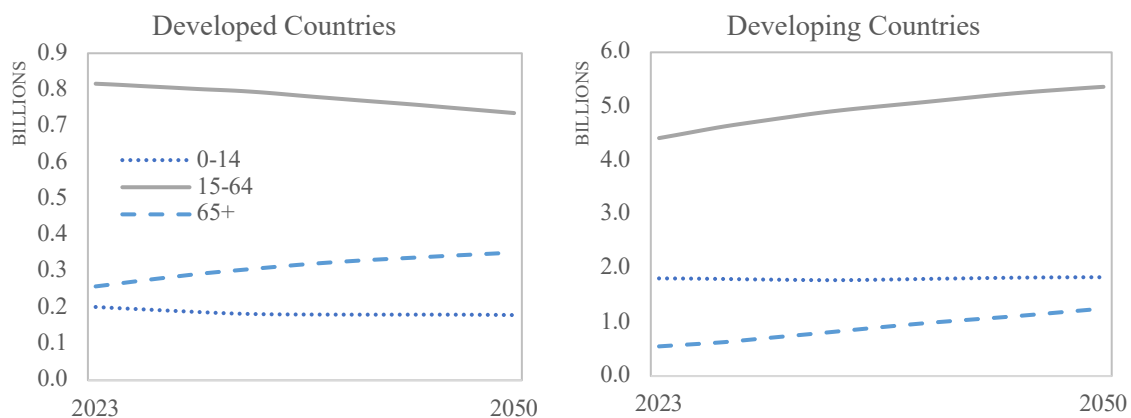


Created with Datawrapper

Note: The medium projection from 2022 to 2100

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

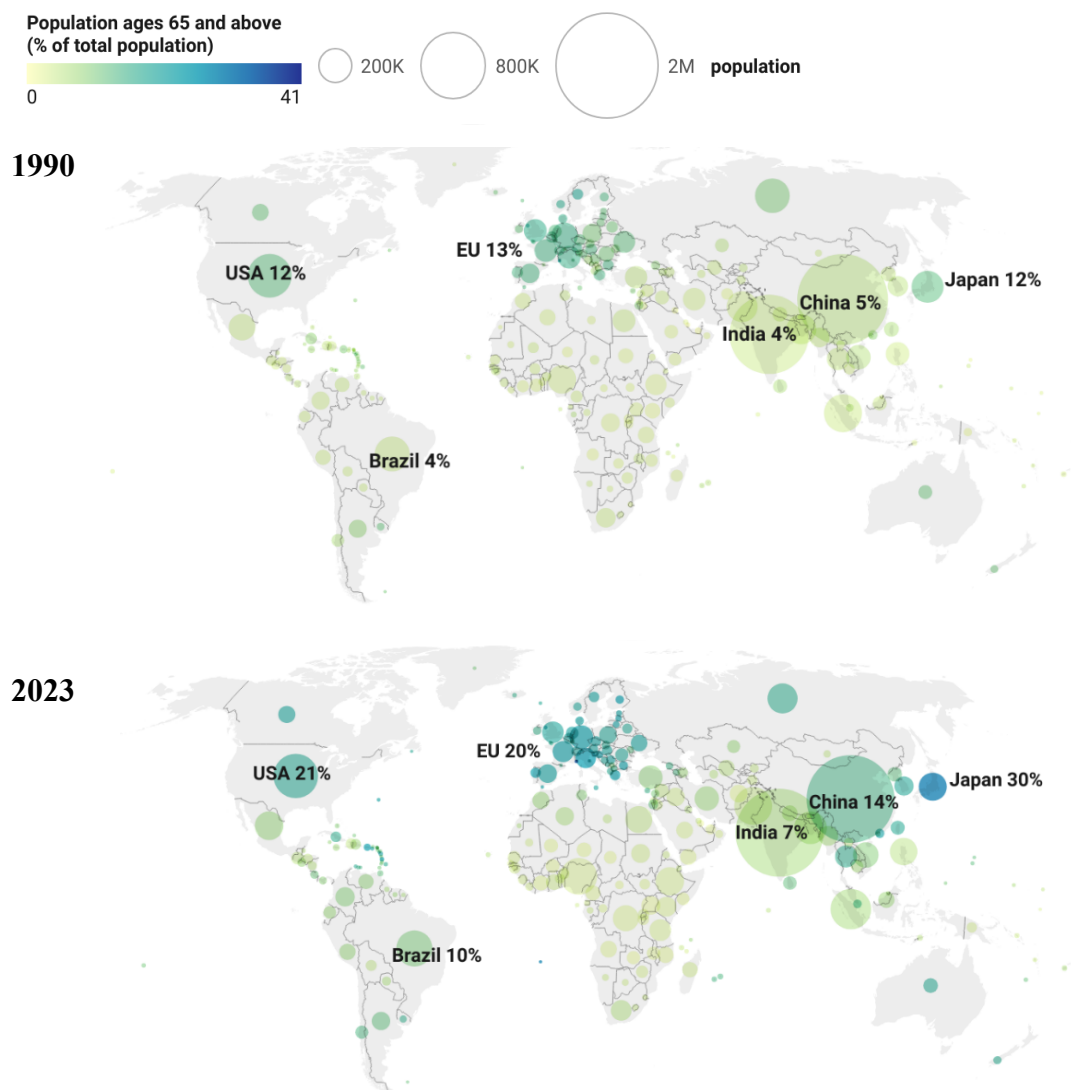
**Figure 2.** Demographic shifts by country groups, 2023-2050



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

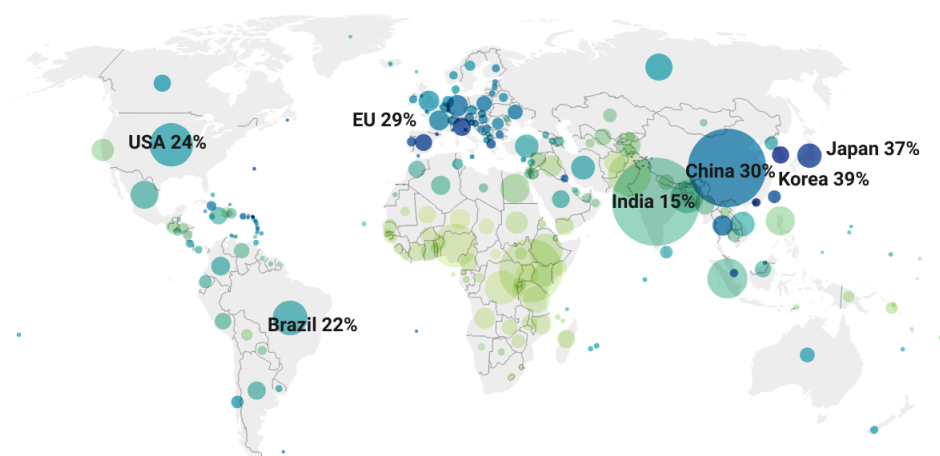
Regarding an increase in the elderly population, countries with a large proportion of the elderly can be divided into three categories: aging, aged, and super-aged.<sup>3</sup> Figure 3 depicts the demographic transition to a super-aged society. Japan experienced the first major shift and is now a super 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 soon follow. South Korea, along with China, will be the next in line by 2050.

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



<sup>3</sup> 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 United Nations, DESA, Population Division, World Population Prospects 2022.

## 2.2 ASEAN food exports

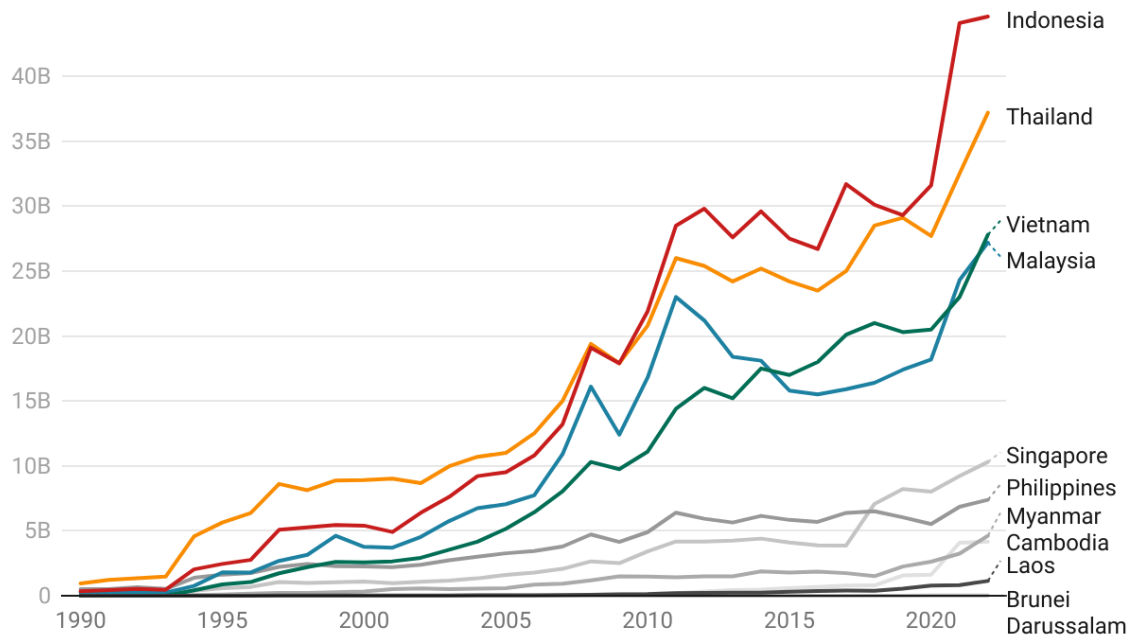
ASEAN countries are the world's leading developing-country food exporters. In 2022, ASEAN countries accounted for approximately 10% of total food imports. More interestingly, ASEAN food exports are concentrated in only four countries: Indonesia, Thailand, Vietnam, and Malaysia. These four countries accounted for roughly 83 percent of ASEAN food exports. In addition, Indonesia and Thailand account for nearly half of all ASEAN food exports.

Overall, ASEAN food exports have increased over the last three decades. Thailand was once the leading exporter among ASEAN countries, but Indonesia has surpassed Thailand as the leading food exporter since the early 2010s. Vietnam's food exports have steadily increased over time. Meanwhile, Malaysian food exports have been relatively volatile, albeit on an upward trend (Figure 4).

Developing countries are now the primary destination markets for ASEAN food exports, accounting for roughly 65 percent of the total in 2022. ASEAN food exports to both developed and developing countries have increased over the last three decades. However, exports to developing countries have increased more dramatically (Figure 5). Since the 2010s, developing countries have been the main destination markets for ASEAN food exports, which are primarily driven by Chinese import demand. Furthermore, over the last three decades, the United States has been the leading first two destination markets for ASEAN exports, followed by another developed country such as Japan. Despite the fact that the European Union (EU) is

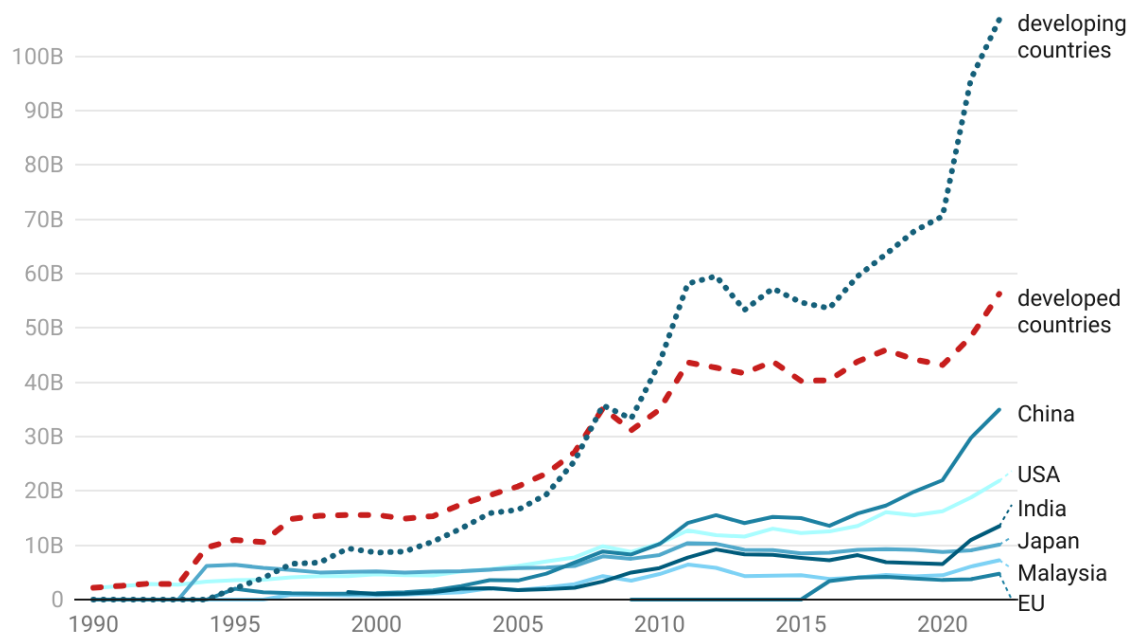
the world's largest importer, ASEAN food exports to the EU increase less than they would otherwise.

**Figure 4.** ASEAN Food exports (Billions USD), 1990-2022



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

**Figure 5.** Destination markets of ASEAN food exports, 1990-2022

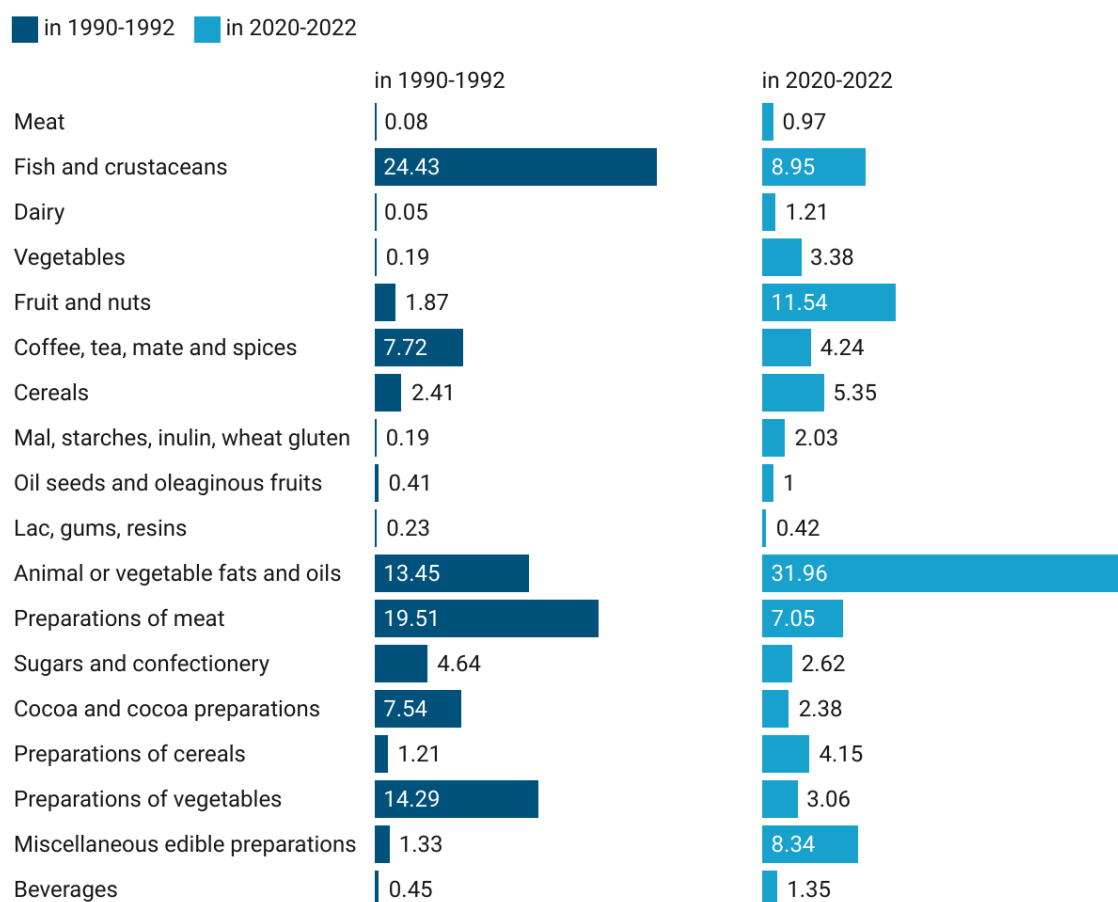


Source: Authors' calculation using the data from S&P Global Market Intelligence

The product composition of ASEAN food exports has changed dramatically over the last three decades. ASEAN food exports in 1990–1992 were primarily fish and crustaceans, processed meat and vegetables, and animal and vegetable fats and oils. However, the product composition is currently concentrated in animal and vegetable fats and oils, accounting for approximately 31% of total ASEAN food exports in 2020–2022, followed by fruits and nuts, fish and crustaceans, respectively (Figure 6).

In 2022, more than half of ASEAN exports of animal and vegetable fats and oils originated from Indonesia, followed by Malaysia (36 percent). Thailand was the largest exporter of fruit and nuts in ASEAN, accounting for nearly half of the region's fruit exports. Furthermore, Vietnam accounted for nearly half of ASEAN fish and crustacean exports, with Indonesia accounting for around 27 percent in 2022.

**Figure 6.** ASEAN Food exports classified by products (% of ASEAN food exports), 1990-1992 vs. 2020-2022



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

### 3. Analytical Framework: Linking Demographics and Food Trade

Changes in population demography can have a variety of effects on both food demand and food production amount. These effects have the potential to have a significant impact on global food trade. The following are main channels via which demographic changes can have a significant impact on worldwide food trade patterns:

On the demand side, 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). On the one hand, 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 and Drewnowski, 2014; Chung, *et al.*, 2007; Helldan, *et al.*, 2016). The elder with financial adequacy (Thompson *et al.*, 2011; Vesnaver *et al.*, 2012) and higher education (Bishop *et al.*, 2020; Shatenstein *et al.*, 2016; Shatenstein *et al.*, 2013) choose better diet. 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). Gender also matters in determining healthy food choices. Ali-Kovero, *et al.* (2020) finds that women after retirement consume less of fruit, vegetable and fish, while men do the opposite. If the hypothesis that the old demands more for healthy food is true, the escalated trade flow is expected.

Regarding the supply aspect, changes in demographics can have considerable impacts on a country's productivity and comparative advantage<sup>4</sup> in the realm of global trade, thus shaping its export trends. Productivity could be age dependent. However, the demographic shifts can result in ambiguous effect on productivity. We first start with productivity.

The relationship between age and productivity is mixed. Theoretical frameworks based on human capital accumulation explains that older workers have been working and accumulating all necessary skills for their jobs, and thus they are more productive (Mincer, 1974; Becker, 1975). Another theoretical foundation on deferred compensation also shows the positive relationship between age and productivity in the sense that the firm discourage works from shirking by paying young workers below their marginal productivity and paying higher later in their career to compensates them (Becker and Stigler, 1974; and Lazear, 1979; 1981). Therefore, older workers after accumulating human capitals are more productive.

In contrast, some literature argue that older workers become less efficient as their cognitive skills deteriorate over time and less willing to learn or be trained with new skills (Daveri and Maliranta, 2007; Maurer, 2001; Lallemand and Rycx, 2009; Hayward et al. 1997). Furthermore, young workers are more motivated to put more efforts so that their employers can observe it as a signal (Grund and Westergaard-Nielsen 2005). Maestas, Mullen, and Powell (2023) used US population aging data across states from 1980 to 2010 and found that the growth effect of aging has a negative effect on productivity. Thus, aging society has an ambiguous effect on the productivity.

When considering age-dependent skills, a country's demographic makeup can influence its comparative advantage in two ways. First, changes in a population's demographics can have an impact on the composition of a country's workforce. According to the Heckscher-Ohlin model, changes in demographic patterns, such as an aging population, can lead to changes in the number and proportionate availability of skills related to different age groups. Because specific abilities evolve throughout an individual's life, the quantities of these skills will differ across persons and, as a result, between countries based on the age distribution of their populations. When skill intensity differs across industries, the Heckscher-Ohlin model shows that a country's age distribution contributes to its comparative advantage. For example, a country with an aging population will excel in producing commodities that rely substantially

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<sup>4</sup> For comparative advantage, it pertains to a country's ability to manufacture specific goods with a lower opportunity cost in comparison to other countries.

on abilities that improve with age. In this case, comparative advantage derives from disparities in skill premia between countries.

Second, when viewed through the Ricardian lens, demographic change can have an effect on comparative advantage. Workers of diverse ages may not perform equally well in tasks requiring age-dependent skills. This disparity can have an impact on labor productivity across industries with varied task compositions. In circumstances where industry-specific skills or labor market restrictions impede the fluid mobility of workers across sectors, the age distribution of workers within each industry will mimic that of the entire country. Consequently, an aging population will change the age composition of the workforce in all sectors, resulting in a rise (or drop) in labor productivity in industries depending on abilities that appreciate (or depreciate) with age. As a result, countries with older populations will have higher Ricardian productivity and a stronger comparative advantage in industries that rely heavily on skills that improve with age.

The most recent research by Cai and Stoyanov (2016) created industry-level measures of intensities in several age-dependent skills. Their findings revealed that as the population ages, there is a trend toward specialization in industries that rely heavily on age-appreciating skills. Simultaneously, this demographic transition erodes competitive advantage in industries that rely intensively on skills that degrade with age.

#### **4. Empirical model**

Tinbergen (1962) was the first to propose the gravity equation, which has since become a popular instrument in empirical research for estimating the trade flow between two countries. Tinbergen (1962) initially introduced the gravity model as an observed phenomenon, whereas Anderson and Wincoop (2003) and Baier and Bergstrand (2010) subsequently established their theoretical underpinnings. According to the previous gravity literature, two main factors primarily drive the bilateral trade flows between two countries:

(i) *Size factors*: the larger the scale of production in a country, the greater the volume of exports it can successfully sell to any trading partners. Likewise, larger countries (in terms of demand) are better placed to import a wider array of products from all exporting nations. As a result, these size-related variables have a positive association with bilateral trade flows.

(ii) *Trade cost factors*: These include both the direct trade costs between the two countries as well as inward and outward multilateral resistance (MR) terms. These costs shed light on the comparative nature of bilateral trade costs in regard to the countries' average costs in dealings with other trading partners.

The empirical gravity model is extended to reflect the possible consequences of demographic shifts on food trade, including both demand and supply implications. The four-dimensional panel analysis is expressed by the following equation:

$$\begin{aligned}
X_{ijpt} = \exp \{ & \alpha_0 + [\alpha_1 \log POP_{it} + \alpha_2 \log POP_{it} * D_{aging_{it}} + \alpha_3 \log POP_{it} * D_{aged_{it}} + \\
& \alpha_4 \log POP_{it} * D_{super_{it}}] + [\beta_1 \log POP_{jt} + \beta_2 \log POP_{jt} * D_{aging_{jt}} \\
& \beta_3 \log POP_{jt} * D_{aged_{jt}} + \beta_4 \log POP_{jt} * D_{super_{jt}} + \\
& \delta_1 \log GDP_{it} + \delta_2 \log GDP_{jt} + \delta_3 Dist_{ij} + \delta_4 Language_{ij} + \delta_5 Colony_{ij} + \delta_6 Contiguity_{ij} + \\
& \delta_7 PTA_{ijt} + \delta_8 Religion + \sum_t \rho_t BOD_{ijt} + \sum_k \gamma_k MR_{ijt}^k + \theta_p + \theta_t \} u_{i,j,p,t} \quad (1)
\end{aligned}$$

where  $X$  denotes bilateral trade.

*The set of demographic variables:*

$POP$  is the total population as a proxy of a demographic variable.

$D_{aging}$  is a time-varying dummy variable that equals 1 if a country's aged population ratio is between 7% and 14%, and 0 otherwise.

$D_{aged}$  is a time-varying dummy variable that equals 1 if a country's aged-population ratio is between 15% and 20%, and 0 otherwise.

$D_{super}$  is a time-varying dummy variable that equals 1 if a country's aged-population ratio is equal to or greater than 21%, and 0 otherwise.

*The set of traditional gravity variables:*

$GDP$  is the size factors of importing and exporting countries

$Dist$  is geographical distance

$Language$  is a dummy variable taking the value of 1 if a country-pair has a common official common language, and 0 otherwise.

$Colony$  is a dummy variable taking the value of 1 if a country-pair shares a common border, and 0 otherwise.

*Contiguity* is a dummy variable taking the value of 1 if a country-pair has a colonial tie, and 0 otherwise.

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

*Religion* is a common religion index of a country-pair.

*BOD* is a time-varying border dummy

*MR* is the set of multilateral resistance term

Also,  $\theta_p$  is the *product* fixed effects and  $\theta_t$  is the set of *specific-time* dummy variables, including (i) a dummy of the global financial crisis ( $D_{GFC}$ ) taking the value of 1 for the years 2008-2009, and (ii) a dummy of post-COVID-19 ( $D_{COVID}$ ) taking the value of 1 for the years 2020 onward.  $u_{ijpt}$  is the error term. The subscriptions  $i$ ,  $j$ ,  $p$ , and  $t$  denote importing countries, exporting countries, product group, and time, respectively.

Aligned with theoretical consistency, Yotov et al. (2016) recommended that the dependent variables ( $X$ ) should encompass both international and international observations.

The demographic variables are the primary focus of this study. *POP* can be treated as a size factor representing food import demand in importing countries. Given limited domestic resources, the demand for food imports is expected to rise as the population grows. This variable's coefficient is expected to be positive. In addition, to capture the trade impact of aging society, the interaction term of *POP* and the dummy variable of intensity levels in older people ( $D_{aging}, D_{aged}, D_{super}$ ) are included in the model. The effects of these variables are inconclusive. Dietary preferences and nutritional needs may shift as a population ages. Older people may develop different dietary preferences, such as a desire for specialized or health-conscious foods. These preferences may increase or decrease demand for specific imported foods. Food imports may decline as a result of an aging society. When compared to younger people, older adults eat smaller portions and have lower calorie requirements. This can lead to a reduction in overall food consumption, including imported foods. However, an aging society may result in an increase in food imports. In some aging populations, older people may have more disposable income than younger people. This may result in increased purchasing power, allowing them to purchase more expensive imported foods.

The other set of demographic variables is for exporting countries. *POP* is another size factor representing export capacity in the context of exporting countries, as total people are a

proxy for labor resources. It is worth noting that the total population is used rather than working-age people because workers in the food and agricultural sectors are generally self-employed, which includes both young and old people, particularly in developing countries. Given that labor resources are a critical determinant in food processing, an increase in the people is expected to strengthen a comparative advantage within the food sector, boosting food exports. This variable's coefficient is likely to be positive. However, the trade impacts of the interaction terms between *POP* and dummy variables of the aging/aged/super aged societies are inconclusive. If workers with age-appreciating skills are required in food production, the coefficients of these interaction terms should be positive.

The gravity model typically includes the following control variables. *GDP* is the size factors of importing and exporting countries. The greater the value of *GDP*, the higher the income and purchasing power of food imports. Similarly, the larger *GDP*, the more advanced the exporting country's food production and export capacity. Thus, the coefficients of these two variables are expected to be positive.

For the set of trade costs between countries. The greater the geographic distance between two countries, the higher the transportation costs and, as a result, the lower the trade flows. Therefore, the distance coefficient (*Dist*) should be negative. Furthermore, if the countries are neighbors with a common border, the proximity could increase trade flows between the two countries. As a result, Contiguity is expected to have a positive effect on trade flow. However, if there are border disputes between the countries, it could be detrimental. A country pair with a common language and a colonial tie may also have lower communication and negotiation costs, as well as a similar food culture. As a result, the *Language* and *Colony* coefficients are expected to be positive. *Religion* is included in the model to capture the trade impact of information-seeking costs for religious foods such as halal food. This variable is expected to have a positive trade impact. *PTA* is the time-varying policy variable. If two countries sign the same trade agreement, the agreement has the potential to facilitate their bilateral trade flows; however, the actual trade impact is dependent on Rules of Origins (RoOs) and other administrative complications. As a result, the sign of the *PTA* coefficient is inconclusive.

In accordance with Bergstrand, *et al.* (2015), a time-varying border dummy variable (*BOD*) is included in the model to capture all bilateral factors influencing international relative to intranational trade on average over time relative to the base period, including common globalization effects. *BOD* is the product of a time dummy and a time-invariant

binary variable, with a value of 1 when the source and destination countries of a trade flow are distinct and a value of 0 when they are the same.

In the theoretical model, the multilateral resistance ( $MR$ ) terms capture the average trade costs that countries face with their trading partners. The coefficients of  $MR$  terms are expected to have the opposite sign as the effects of their corresponding bilateral trade costs. For example, the greater the distance between country  $j$  and its trading partners, the greater country  $j$ 's trade with country  $i$ .

## 5. Data sources and econometric issues

The trade equation is estimated using a four-dimensional panel dataset (*exporter-importer-product-time*) of food exporters from 1990 to 2022. It covers the exports of 10 ASEAN member countries<sup>5</sup> with 105 trading partners.<sup>6</sup> Based on the most recent United Nations country classification, importing countries are divided into developing and developed country groups.<sup>7</sup>

Food export data is derived from trade data based on the Harmonized System Code (HS Code) at the 2-digit level, which includes 18 chapters.<sup>8</sup> In addition, we adhere to the definition of healthy diets proposed by the World Health Organization (WHO). The healthy food products are identified at the 6-digit level based on the HS code and then aggregated to the 2-digit level.

Furthermore, mirror export statistics are a measure of food trade data. As noted by Yotov et al. (2016), 'mirror export' data—import data of destination countries as a measure of

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<sup>5</sup> ASEAN countries consist of Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam.

<sup>6</sup> The importing countries included in this study: Albania, Algeria, Angola, Argentina, Australia, Austria, Azerbaijan, Bahrain, Belarus, Belgium, Belize, Bolivia, Botswana, Brazil, Brunei Darussalam, Bulgaria, Canada, Chile, China, Colombia, Congo, Costa Rica, Cyprus, Czechia, Côte d'Ivoire, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Ethiopia, Finland, France, Georgia, Germany, Ghana, Greece, Guatemala, Honduras, Hong Kong, Hungary, Iceland, India, Indonesia, Ireland, Israel, Italy, Japan, Jordan, Kazakhstan, Kenya, South Korea, Kuwait, Kyrgyzstan, Latvia, Lithuania, Luxembourg, Macao, Malaysia, Malta, Mauritius, Mexico, Morocco, Mozambique, Namibia, the Netherlands, New Zealand, Nicaragua, Nigeria, Norway, Pakistan, Panama, Paraguay, Peru, the Philippines, Poland, Portugal, Puerto Rico, Qatar, Republic of North Macedonia, Romania, Russian Federation, Rwanda, Senegal, Singapore, Slovakia, Slovenia, South Africa, Spain, Sri Lanka, Sweden, Switzerland, Tanzania, Thailand, Togo, Tunisia, Turkey, Ukraine, United Kingdom, the United States, Uruguay, Uzbekistan, Vietnam, Zambia, Zimbabwe.

<sup>7</sup> 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/>

<sup>8</sup> See Appendix Table A.1 for the list of healthy food products.

<sup>9</sup> Chapters 02, 03, 04, 07, 08, 09, 10, 11, 12, 13, 15, 16, 17, 18, 19, 20, 21, 22

exports from origin exporting countries—is traditionally considered more reliable because imports are subject to closer scrutiny and monitoring by customs administrations.

The size factors of exporting and importing countries are measured by Gross Domestic Product (GDP) for each country. It is worth noting that these variables are not adjusted for inflation, which aligns with the methodologies of Yotov et al. (2016) and Head and Mayer (2014).

The data are from several sources. The food trade data are collected from S&P global market intelligence database. The data on preferential trade agreement are retrieved from Asia Regional Integration Center, organized by Asian Development Bank (ADB). The Gross Domestic Product (GDP), population (*POP*), and the aged-population ratio series across countries are collected from the World Bank database. The data on other gravity variables are extracted from Centre d'Études Prospectives et d'Informations Internationales (CEPII)

Considering the existence of zero trade flows is a significant obstacle encountered 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). In order to effectively account for the presence of zero trade flows, the trade equation is estimated using a multiplicative form, as shown in equation (1).

This study employs the Poisson pseudo-maximum likelihood (PPML) method developed by Silva and Tenreyro (2006) due to the non-linear nature of the trade equation's parameters and the inclusion of zero trade data. The PPML has the advantage of generating estimates that are both consistent and unbiased, as well as results that are resistant to various types of heteroscedasticity. Importantly, Yotov et al. (2016), Shepherd (2013), and Crivelli and Gröschl (2016) show that this method is effective even when a significant proportion of zero trade flows exist.

Appropriate approximation of multilateral resistance terms (MR) is a further challenge when estimating the gravity model. This study used the consistent multilateral resistance (MR) terms measurement proposed by Baier and Bergstrand (2010). The primary advantage of this method is that MR terms can be explicitly incorporated into the model and no time-varying variables are omitted. This method is also used in a number of recent pieces of gravity-related literature (e.g., Melitz, 2008; Ehrich and Mangelsdorf, 2018) In practice, *importer-time* fixed effects and *exporter-time* fixed effects are commonly used as proxies for multilateral resistances in previous literature because they can absorb observable and unobservable

country-time-specific impacts (Olivero and Yotov, 2012; Baldwin and Taglioni, 2006; Rose and van Wincoop, 2001; Ferro et al., 2013; Shepherd, 2013; Crivelli and Groschl, 2016). However, using these fixed effects prevents us from examining the effects of time-varying independent variables associated with exporting and importing countries. They also result in a significant loss of degrees of freedom, which is problematic for the model.

## 6. Results

The estimated trade impact of population growth is shown in Table 1. The findings indicate that the overall effects of population growth are positive and statistically significant in both importing and exporting countries. More specifically, a 1% increase in the global population can increase import demand for ASEAN food exports by around 0.3%. Similarly, a 1% increase in an exporting country's population increases food exports by 0.34 percent. It is worth noting that the magnitude effects of population are smaller than those of *GDP*, the traditional size factors, whose coefficients are 0.8, as also obtained in Suanin (2023). Furthermore, the estimates are classified by destination markets. The findings support the claim that an increase in the population of the exporting country can stimulate ASEAN food exports to developing countries and the EU markets (Table 1, columns 3 and 5).

The model then accounts for changes in the population's age distribution by including an interaction term between *POP* and a set of three binary variables that measure the intensity of the older population. Based on the estimates presented in Table 2, it can be observed that an expanding population coupled with a greater proportion of elderly people in importing countries has the potential to diminish the demand for ASEAN food imports. This effect is particularly pronounced in importing countries that have reached a superaged demographic status. Furthermore, estimates for developed countries and the EU market confirm these findings, with the coefficients of the interaction terms being significantly negative and the magnitude of the absolute term increasing with elderly people proportion (column 2). In contrast, it has been observed that the import demands for ASEAN food exports tend to increase when both the United States and China experience demographic shifts towards aging societies.

**Table 1.** The estimated food exports of ASEAN countries classified by destination markets

	(1)	(2)	(3)	(4)	(5)	(6)
	world	Developed countries	Developing countries	USA	EU	China
Log POP <sub>importer</sub>	0.03** (0.02)	-0.40 (0.25)	0.02 (0.01)	0.31 (1.32)	-0.57 (0.44)	4.40 (5.33)
Log POP <sub>exporter</sub>	0.34*** (0.07)	0.10 (0.09)	0.37*** (0.11)	0.10 (0.16)	0.47** (0.19)	-0.09 (0.20)
Log GDP <sub>importer</sub>	0.80*** (0.05)	1.35*** (0.24)	0.58*** (0.06)	2.11 (1.97)	1.78*** (0.44)	0.04 (0.66)
Log GDP <sub>exporter</sub>	0.84*** (0.06)	0.89*** (0.12)	0.81*** (0.08)	1.06*** (0.14)	0.48*** (0.17)	1.05*** (0.17)
Log Dist	-0.42*** (0.07)	-0.17 (0.40)	-0.48*** (0.08)		0.12 (0.25)	
contiguous	0.62* (0.36)		0.50 (0.34)			
language	0.21 (0.28)	-0.14 (0.15)	0.64* (0.38)		-0.70 (0.57)	
colony	1.09*** (0.30)	2.13** (0.84)	0.95*** (0.26)		2.40*** (0.62)	
PTA	0.14 (0.14)	0.35* (0.19)	0.38 (0.25)	-1.73*** (0.14)	0.36 (0.45)	-8.68 (15.91)
religion	0.51 (0.54)	-0.23 (0.26)	1.53* (0.92)	9.81 (19.35)	-0.33 (0.29)	-42.18 (38.74)
D_GFC	-2.21*** (0.67)	-0.22** (0.09)	-1.72** (0.80)	2.10 (1.29)	1.81* (1.00)	0.74 (0.73)
D_Covid	-3.55*** (0.54)	-0.74*** (0.20)	-2.92*** (0.63)	0.25 (1.27)	0.04 (0.87)	1.13 (1.50)
constant	-31.77*** (2.09)	-37.93*** (5.22)	-26.02*** (2.48)	-80.94** (36.52)	-45.54*** (7.92)	-92.37 (105.02)
BOD	yes	yes	yes	yes	yes	yes
MR	yes	yes	yes	yes	yes	yes
Pseudo R <sup>2</sup>	0.66	0.70	0.67	0.68	0.61	0.73
No. of Obs.	425,588	136,853	219,324	7,996	79,882	7,133

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

In the case of exporting countries, the results show that the coefficient of the interaction term is mostly statistically significant (Table 2, column 1). That is, an aging society increases ASEAN countries' comparative advantage in exporting food products, particularly to developed country markets such as the United States and the European Union (columns 2, 4, and 5).

Table 3 shows the estimates for healthy food exports. When compared to previous results, the findings are more robust. Import demand for healthy food exports from ASEAN countries can rise as the population of importing countries grows. However, demand decreases

when importing countries have a higher elderly population ratio. The findings also support the claim that an increase in the population of aging people supports ASEAN countries' healthy food exports.

**Table 2.** The age distribution effect on food exports of ASEAN countries classified by destination markets

	(1) world	(2) Developed countries	(3) Developing countries	(4) USA	(5) EU	(6) China
Log POP <sub>importer</sub>	0.04*** (0.02)	-0.25 (0.23)	0.04* (0.02)	3.94 (6.71)	-0.57 (0.38)	-14.34 (15.15)
Log POP <sub>importer</sub> *D <sub>aging</sub>	-0.01 (0.01)		-0.01 (0.01)			0.04* (0.02)
Log POP <sub>importer</sub> *D <sub>aged</sub>	-0.01 (0.01)	-0.02*** (0.01)	-0.01 (0.02)	0.04* (0.02)	-0.04*** (0.01)	
Log POP <sub>importer</sub> *D <sub>super</sub>	-0.03** (0.01)	-0.03** (0.01)			-0.07** (0.03)	
Log POP <sub>exp</sub>	0.43*** (0.07)	0.21*** (0.08)	0.40*** (0.11)	0.41 (0.38)	0.53*** (0.17)	-0.30 (0.58)
Log POP <sub>exp</sub> *D <sub>aging</sub>	0.02*** (0.01)	0.03*** (0.01)	0.00 (0.01)	0.00 (0.01)	0.03*** (0.01)	-0.02 (0.01)
Log POP <sub>exp</sub> *D <sub>aged</sub>	0.03*** (0.01)	0.05*** (0.01)	0.01 (0.01)	0.03*** (0.00)	0.01 (0.02)	0.00 (0.03)
Log GDP <sub>imp</sub>	0.86*** (0.04)	1.25*** (0.23)	0.61*** (0.05)	-3.71** (1.64)	1.89*** (0.45)	0.77 (0.77)
Log GDP <sub>exp</sub>	0.72*** (0.05)	0.78*** (0.11)	0.81*** (0.09)	1.23*** (0.22)	0.39** (0.17)	1.55*** (0.49)
Log Dist	-0.40*** (0.07)	-0.57 (0.35)	-0.51*** (0.07)	-16.47* (10.01)	2.19*** (0.83)	0.67 (6.34)
contiguous	0.50 (0.43)		0.51 (0.38)			-1.35 (1.96)
language	0.29 (0.28)	-0.04 (0.15)	0.69* (0.40)	-4.77 (3.19)	-1.06** (0.53)	1.83 (2.22)
colony	1.07*** (0.29)	1.33 (0.84)	0.93*** (0.25)		2.08*** (0.63)	
PTA	0.30*** (0.11)	0.38* (0.20)	0.37 (0.24)	-0.02 (0.30)	0.27 (0.41)	-0.00 (0.46)
religion	0.57 (0.52)	0.18 (0.26)	1.49 (0.96)	9.93 (16.57)	0.13 (0.38)	-254.16 (284.51)
D_GFC	-2.17*** (0.62)	-0.15 (0.10)	-1.70** (0.81)	-0.03 (0.04)	0.09 (0.16)	0.16 (0.40)
D_Covid	-3.59*** (0.56)	-0.66** (0.27)	-2.92*** (0.65)	0.10 (0.39)	0.27 (0.28)	0.45** (0.22)
constant	-32.06*** (2.00)	-32.78*** (4.66)	-27.27*** (2.44)	172.09 (142.57)	-66.08*** (12.98)	254.60 (311.32)
BOD	yes	yes	yes	yes	yes	yes
MR	yes	yes	yes	yes	yes	yes
Pseudo R <sup>2</sup>	0.67	0.71	0.68	0.68	0.62	0.72
No. of Obs.	425,588	136,853	219,324	4,746	77,234	4,252

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

**Table 3.** The estimated healthy food exports of ASEAN classified by destination markets

	(1) world	(2) Developed countries	(3) Developing countries	(4) USA	(5) EU	(6) China
Log POP <sub>importer</sub>	0.04*** (0.02)	-0.25 (0.23)	0.04* (0.02)	3.94 (6.71)	-0.57 (0.38)	-14.34 (15.15)
Log POP <sub>importer</sub> *D <sub>aging</sub>	-0.02 (0.02)		-0.02 (0.02)			0.06* (0.03)
Log POP <sub>importer</sub> *D <sub>aged</sub>	-0.02 (0.02)	-0.02*** (0.01)	-0.01 (0.03)	0.01** (0.002)	0.005 (0.03)	
Log POP <sub>importer</sub> *D <sub>super</sub>	-0.04* (0.02)	-0.03** (0.01)			0.003 (0.04)	
Log POP <sub>exp</sub>	1.01*** (0.14)	0.95*** (0.23)	0.86*** (0.17)	1.33*** (0.17)	0.15* (0.07)	0.22 (0.30)
Log POP <sub>exp</sub> *D <sub>aging</sub>	0.05*** (0.01)	0.03* (0.02)	0.04*** (0.01)	0.02* (0.01)	0.01*** (0.004)	-0.01 (0.02)
Log POP <sub>exp</sub> *D <sub>aged</sub>	0.07*** (0.01)	0.02 (0.02)	0.06*** (0.02)	0.03*** (0.01)	0.02*** (0.005)	0.003 (0.02)
Log GDP <sub>imp</sub>	0.82*** (0.06)	0.89*** (0.19)	0.63*** (0.11)	-2.39 (1.67)	1.08*** (0.34)	1.35* (0.78)
Log GDP <sub>exp</sub>	0.17* (0.09)	-0.03 (0.22)	0.31*** (0.10)	1.25*** (0.14)	0.51*** (0.06)	0.94*** (0.24)
Log Dist	-0.87*** (0.15)	-0.76** (0.31)	-0.80*** (0.19)	-12.23*** (4.61)	-0.18*** (0.06)	3.42* (1.78)
contiguous	0.06 (0.56)		0.01 (0.57)		1.07*** (0.16)	-1.23*** (0.42)
language	-0.48* (0.28)	-0.87*** (0.27)	-0.88 (0.56)	12.43*** (1.13)	0.25 (0.17)	-1.84* (1.12)
colony	1.88** (0.92)	1.59*** (0.50)	1.73* (0.91)		-2.36*** (0.91)	
PTA	0.17 (0.21)	0.23 (0.16)	0.15 (0.36)	-1.60*** (0.47)	1.06*** (0.13)	0.52 (0.65)
religion	-2.30 (1.54)	-4.83*** (0.74)	-3.91** (1.79)	-49.91*** (4.43)	0.12 (0.24)	-279.00* (142.69)
D_GFC	-3.34*** (0.83)	0.23** (0.09)	-2.90*** (1.01)	-0.56*** (0.13)	-0.06 (0.07)	-0.52 (0.33)
D_Covid	-3.92*** (0.97)	0.69** (0.28)	-3.54*** (1.04)	0.06 (0.15)	0.28*** (0.06)	0.24 (0.22)
constant	-23.40*** (2.92)	-20.73*** (4.91)	-20.68*** (3.48)	111.74 (139.31)	-24.01*** (5.88)	337.98 (287.32)
BOD	yes	yes	yes	yes	yes	yes
MR	yes	yes	yes	yes	yes	yes
Pseudo R <sup>2</sup>	0.74	0.76	0.71	0.85	0.59	0.87
No. of Obs.	309,992	101,321	47,885	3,404	218,816	920

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

## 7. Conclusion and Policy implications

Despite a decline in fertility rates, the world's population will grow over the next three decades, with younger people outnumbering older people. Because people of different ages have different dietary preferences and unique requirements for the essential foods they consume, changes in population composition may have an impact on the pattern of food trade. Demographic changes in age distribution may also affect exporting countries' comparative advantage in exporting food products. Using structural gravity analysis, the study examines the impact of demographic shifts toward an aging society on ASEAN food exports from 1990 to 2022.

There are three major conclusions. First, the increasing population of importing countries increases import demand for ASEAN food exports. However, demand decreases when importing countries have a greater proportion of elderly people, especially in developed countries and the EU markets. Second, given an increase in their aging populations, the United States and China are potential importers of ASEAN food exports. Third, an increase in population toward an aging population (a workforce with age-appreciating skills) in ASEAN countries improves their comparative advantage in food production and thus their food exports. Finally, these findings apply to healthy food products as well.

Based on the results of the study, the following policy implications can be drawn: The first is to diversify export strategies. ASEAN countries should consider diversifying their food export strategies in response to shifting demographic patterns. In the context of the demographic transition to an aging population, this study highlights the United States and China as potential markets. Exploration of new markets or product categories may thus yield advantageous results.

The second is to tailor export products. To capitalize on the growing demand for ASEAN food exports, particularly in markets such as the United States, China, and the European Union, exporting countries should tailor their products to the preferences of the destination countries. This could include emphasizing healthy food products, as ASEAN trading partners appear to have a greater appetite for such items.

The final point is to address the aging workforce. Given the demographic shift toward an aging population, exporting countries have to deal with labor shortages in agriculture and food production. Policies that promote the development and training of the aging workforce can be critical.

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**Table A.1** List of healthy food products (HS code)

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**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

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**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,

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**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,

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**IV. Oil**

150410, 150420, 150710, 150790, 150910, 150990, 151211, 151219, 151410, 151490,

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**V. Beverages**

220110, 220190

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