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AGEING POPULATIONS AND WORLD TRADE: BLIGHT OR BLESSING?

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Since the last half of the twentieth century, population ageing has increasingly become a problem for countries all over the world. The literature on population ageing is very well-established, however, it is lacking in one significant respect. That is, hardly any research has been done on how population ageing may affect international trade. Therefore, this thesis seeks to establish this effect. As populations age, their old-age demographic dependency ratios increase. Furthermore, following life-cycle theory, the private consumption of the elderly decreases. With these facts in mind, an extensive gravity model of international trade is estimated, to gauge the effect of ageing on international trade, both through the use of dependency ratios, as well as self-constructed consumption ratios. Data from the NTA and AGENTA projects are used for these. I find support for my hypotheses that bilateral trade decreases as the dependency ratio of the importer, or the consumption ratio of the importer increases, but I find only partial support for my hypothesis that bilateral trade decreases in categories where the elderly are expected to consume less. Still, I find that the population age structure, and thus population ageing, influences bilateral trade, which is highly relevant for our ageing world.

Keywords: population ageing, international trade, gravity model of international trade

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1. INTRODUCTION

Worldwide, countries are witnessing rapid rates of population ageing. This process, which entails a shift in a population's age distribution to older ages, is troubling policymakers not only in developed countries, but increasingly so in developing countries, too (Bengtsson, 2010; Jafrin, Mahi, Masud & Gosh, 2021). This can be seen in Figure 1. Nearly all the world's regions are experiencing a shift towards higher shares of people aged 65 years and over. As can be seen in the figure, this shift is most pronounced in Europe and North America, as well as Australia and New Zealand, and Eastern and South-Eastern Asia (United Nations, 2019). Still, virtually all countries are seeing their population's shares of elderly increase, and this increase is predicted to continue (Bengtsson, 2010; United Nations, 2015). For example, Sweden saw its share of people aged 65 years and over increase from 8% to 17% between 1900 and 2000, and the prediction is that it will rise even further, to reach 24% in 2050 (Bengtsson & Scott, 2010). A similar picture can be painted for, for example, Japan, Puerto Rico, and South Korea (United Nations, 2022).

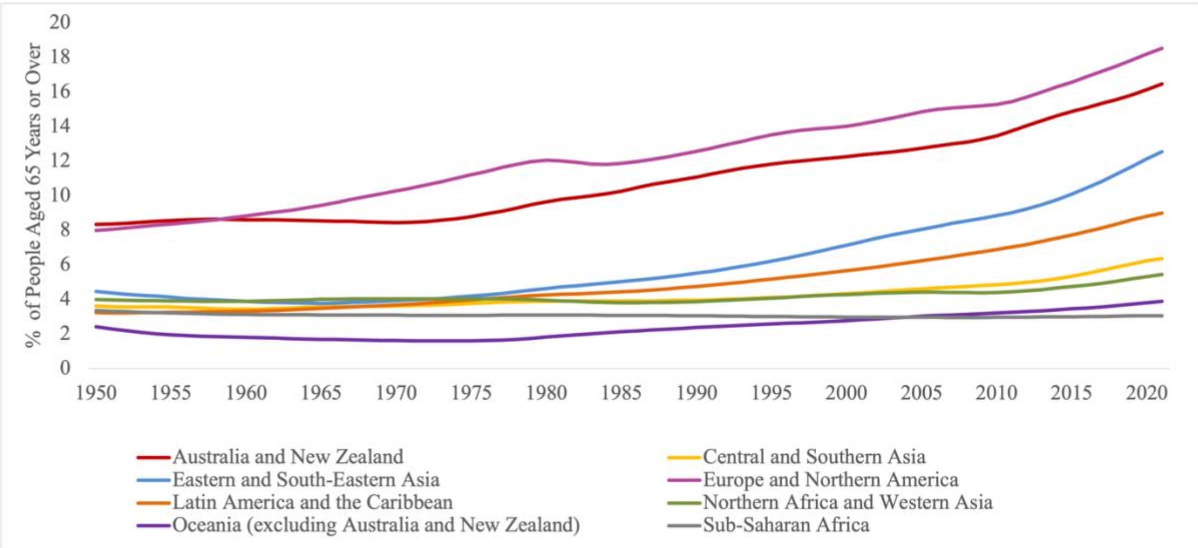

Figure 1. Share of population aged 65 years or over, over time, varying by SDG region
Source: United Nations (2022).

Population ageing is not a new phenomenon, however, as some developed countries already started experiencing ageing in the early 20th century (United Nations, 2015). It is only recently that it has started to become a problem, hence its policy importance. Namely, population ageing can be divided into two stages (Bengtsson & Scott, 2011). In the first stage, the increasing share of elderly is still compensated for by the fast decline in fertility. This fertility decline led to a decrease in the share of youth, which more than compensated for the increase in the share of elderly, even leading to a decline in the demographic dependency ratio. In this stage, the working ages are thus strengthened, and population ageing is thus beneficial (Ehmer, 2017; Bengtsson & Scott, 2011). However, in the second stage, the current stage, ageing starts to become a problem. In this stage, fertility levels have stabilised at low levels and ageing becomes driven by a decline in old-age mortality rates, which pushes dependency ratios upwards (Bengtsson & Scott, 2011). The increase in life expectancy leads people to spend more time outside the labour force than in it, contrary to the increased time spent in the labour force during the first stage (Bengtsson, 2010; Lee, 1994; Rau, 2017). Therefore, ageing in the second stage puts pressure on how consumption of the elderly is funded, leading it to affect economic growth, and therefore potentially trade, too.

It can thus clearly be stated that population ageing will have far-reaching economic effects. Indeed, much attention has been devoted to how population ageing may influence pension systems. Namely, with an increasingly higher number of retirees relative to the number of people in the labour force, the budgetary pressure on pensions rises (Lindert, 2004). For example, Blake and Mayhew (2006) research the viability of the pension system of the United Kingdom. Similar analyses have also been done for other countries, such as China (Li & Mérette, 2005) or Belarus (Lisenkova & Bornukova, 2017).

Another part of the population ageing literature is aimed at the effect of population ageing on inequality, where a positive effect is often found (Deaton & Paxson, 1994). The channel through which population ageing leads to rising inequality is still heavily debated, though, as not all explanations seem to be complete (Wang, Wan, Luo & Zhang, 2017).

Research has also considered the effect of ageing on economic growth. Bloom, Canning & Fink (2011) have researched this effect and have considered the channels of labour-force participation as well as savings rates. An ageing population will have lower labour-force participation rates and savings rates. Consequently, less labour and less capital flow into ageing economies, which could have strong effects on economic growth as the ability to expand production decreases. However, this effect is different for every country, as economic behaviour and policies are of high importance in its mitigation (Bloom et al., 2011). Maestas, Mullen and Powell (2016) estimate the effect of population ageing on GDP growth in the United States. They, too, find that the size of the labour force is an important channel, but even more so is the slower growth in labour productivity of workers over the age distribution.

The effect of population ageing on consumption has also been reviewed. Specifically, according to the life-cycle hypothesis, consumption expenditures differ over the life cycle

(Modigliani & Brumberg, 1954). Stöver (2012) considers the link between population ageing and consumption in Germany, whereas Lefèbvre (2006) has done so for Belgium. Both consider the sectoral composition of consumption and find that there are indeed effects of a changing population age structure on the structure of aggregate consumption.

There is thus no lack of research on the economic effects of population ageing. Nonetheless, there is one area that has been widely overlooked, namely, the effect of population ageing and international trade (Tian, Yao, Yu & Zhou, 2011). Given the numerous effects of ageing that are found on economic factors relevant to trade, such as economic growth and consumption, it comes as a surprise that this effect has not been given proper attention.

Where research has been done on the relationship between population and trade, population is given a very rudimentary role. For example, Maddison (1995) considers the effect of population growth on trade. However, this view is very simplistic, as it disregards many important qualities of the population, such as its age structure. As the changes visible in Figure 1 point out, this characteristic should not be omitted. One needs to consider, for example, which share of the population might be productive, to draw meaningful conclusions about population growth and trade growth.

The research that does exist on population age structures and trade only examines topics related to trade, not necessarily international trade itself. Examples of this research are the influence of age structure on comparative advantages and trade openness (see Cai & Stoyanov, 2013, and Fukumoto & Kinugasa, 2017). Significant effects are found between population ageing and these trade-related constructs. Still, the only paper that, as of yet, considers the relationship between age structure and international trade directly, is that of Tian et al. (2011). They contend that demographic structure has both a scale and a structural effect on trade, where the scale effect refers to how a low demographic dependency ratio of the exporter allows them to produce and thus export more, and where the structure effect refers to how the export composition changes as factor endowments change (Tian et al., 2011). They analyse a gravity model of international trade on a panel dataset with 176 countries from 1970 to 2006. The evidence they find is consistent with their predictions, as both the dependency ratios of the exporter, as well as the importer, show a significant negative effect. However, the gravity model that they utilise is rather narrow; many of the gravity variables that the literature deems required, are missing (Tian et al., 2011; Yotov, Piermartini, Monteiro & Larch, 2016).

Therefore, this research will analyse how a population's age structure influences international trade by utilising a more widely accepted specification of the gravity model of international trade, augmented with several variables to proxy for population age structure. This research is a continuation of my previous thesis, where I also considered the impact of population ageing on international trade through the use of demographic dependency ratios (Meijer, 2022). Still, I make a clear contribution to the literature. Namely, this research contributes to the literature on population ageing, in particular, the strand focusing on international trade, which is heavily underdeveloped. As elaborated upon above, no research focuses directly on the effect of ageing on international trade, apart from the analyses by Tian et al. (2011). The model specified in this research is, therefore, a wider specification of the gravity model than theirs, taking into account more relevant variables (Tian et al., 2011, see also Meijer, 2022). What this research seeks to add above all, and what it expands upon relative to my previous work, is the consideration of the effect of the changing consumption structure of ageing populations, following the life-cycle theory (Modigliani & Brumberg, 1954). Namely, the level of private consumption throughout the life course is expected to affect import demand. To that end, this research focuses on the population age structure of the importing country. Therefore, the following research question is defined:

"Does the age structure of the importer's population influence the level of bilateral trade?"

To aid in answering this research question, three sub-research questions can be defined. First, *"Does the dependency ratio of the importer influence the level of bilateral trade?"*, and second, *"Does the change in consumption over the life course influence the level of bilateral trade as populations age?"*, and third, *"How does bilateral trade change as populations age?"* These research questions are answered using three datasets. The first is a panel dataset considering 38 importing countries and 199 exporting countries in multiple years between 1980 and 2019, the second is a cross-sectional dataset considering 25 European importing countries and 199 exporting countries in the year 2010, the third is a disaggregated version of the same cross-sectional dataset considering 25 European importing countries and 199 exporting countries in the year 2010. The first sub-research question shall be answered using old-age demographic dependency ratios based on data from the United Nations (2022). I find support for my hypothesis that the importer's dependency ratio has a significant negative effect on bilateral trade. The second sub-research question shall be answered using newly calculated *consumption ratios* based on data from the NTA project and the AGENTA project, and as such will take into account both changing age structures, as well as changing private consumption levels throughout the life course. I again find support for my hypothesis that the importer's consumption ratio has a significant negative effect on bilateral trade. To further dive into the reason behind these effects, I also estimate several models where trade is disaggregated into different industries, to see which industries might be driving this negative effect. These models shall be used to answer the third sub-research question, through which I find only partial support for my hypothesis that the importer's consumption ratio has a significant negative effect on trade categories of which the elderly are expected to consume relatively little.

In Section 2, I will elaborate upon the literature. I examine the literature on population ageing and its economic consequences, international trade, and life cycle theory, respectively. This section gives a good view of the gap in the literature that this research intends to fill. Section 3 shall discuss the methodology of the gravity model that is to be estimated, as well as the characteristics of the datasets that are used to estimate the models. Section 4 carefully examines all estimations. It will first review the estimations with the old-age demographic dependency ratios and the estimations with the consumption ratios, then turn to some sensitivity analyses, and then consider the disaggregated estimations with the consumption ratios. Finally, Section 5 discusses the implications of the results, the limitations of this research, as well as the recommendations for future research, and concludes. As this research is a continuation of my previous work, there may be some overlap in several sections. This is the case for Section 2, which considers some of the same sources, and Section 3, as the parts of the methodology and data are similar.

2. LITERATURE REVIEW

Population ageing has gained much attention since the second half of the 20th century. Though theories about the population's age distributions have already been around for quite some time, the world's population still had a very young age structure. Population ageing was thus not an issue, even though many Western countries were already well into their demographic transition (Goldstein, 2009). This has changed drastically since the 1960s, as fertility decreased and life expectancy rose (Bengtsson, 2010; Goldstein, 2009).

The process of population ageing started in Western Europe, where it was driven primarily by fertility declines (Bengtsson & Scott, 2010). It is often assumed that longevity increases are the main cause of population ageing, however, the process is unmistakably more complicated than that. Indeed, individual ageing is not the same as population ageing. Coale (1957) demonstrated the importance of fertility decline by showing that the age structure would have remained unchanged were it not for the decreasing fertility rates. Specifically, fewer births reduce the share of young persons in society and ultimately lead to a higher share of the elderly. It was only when fertility rates stabilised at low levels, therefore, that increased life expectancy started to propel population ageing. Videlicet, up until then, increases in longevity were driven by reductions in infant and child mortality, which only resulted in a rejuvenation of the population as more people in younger age groups remained. However, when longevity increases started to be driven by old-age mortality decreases, as fewer people were taken out of older age groups, it started to contribute to population ageing (Bengtsson, 2010; Bengtsson & Scott, 2011; Goldstein, 2009; United Nations, 2015).

As hinted at in the introduction, population ageing has widespread effects. This section seeks to review research in several strands of ageing literature, and proposes hypotheses to aid in this research. First, a closer look will be taken at several economic consequences of population ageing, to highlight the interconnectedness of demography and the economy. Then, the sparse literature on population ageing and international trade will be further elaborated upon, which demonstrates a clear gap in the literature. There is some degree of overlap between this section and my previous work (Meijer, 2022). Finally, the literature on population ageing and consumption life-cycle theory will be reviewed. This aids in the explanation of how this thesis intends to expand the demography and trade literature.

2.1. Population Ageing and its Economic Consequences

The effects of population ageing are already far-reaching. Ageing is a result of the worldwide progression in health and well-being, which reduces the mortality risks worldwide and allows people to live longer and healthier (United Nations, 2015). This undoubtedly has many positive effects, for example as individuals have better opportunities to pursue new interests or new careers later in life, as families receive support from the elderly both financially as well as with household work, and as societies benefit from civic contributions of the elderly (Ehmer, 2017; United Nations, 2015). Nevertheless, population ageing is plagued by many negative effects, as the advancement of health and well-being are leading to concerns (Rowland, 2009).

Namely, as Ehmer (2017) expresses, as a result of ageing, we now see the very institutions that were meant to promote health and well-being under pressure. Unarguably the most attention in the literature is devoted to the effects of population ageing on pension systems. It is a prime example of an institution under pressure by population ageing (Ehmer, 2017; United Nations, 2015). That is, in many countries, old-age demographic dependency ratios are on the rise. These countries are experiencing a starkly increasing number of older persons, whereas the number of people supporting these older persons, in essence, those of working ages, is decreasing (Bloom et al., 2011; United Nations, 2015). Many countries in Europe and Latin America have pension systems with a high share of public transfers. Population ageing for these systems is highly problematic, as ageing increases the fiscal pressure on these systems, reducing their viability (United Nations, 2019). Specifically, the support ratio decreases as there are increasingly fewer workers for every elderly person, and the amount of pension pay-out sums rise as life expectancy increases (Lindert, 2004; United Nations, 2019). Contrastingly, in systems where more weight is put on support from within the family, a lot of uncertainty arises as to how the elderly can finance their consumption (United Nations, 2019). Ageing namely reduces the number of familial caregivers, be it for monetary or other support, and increased life expectancy may lead to a higher demand for those caregivers (Kohli, 2017). The complex contrast in the pressures that arise in both systems illustrates the need for sustainable support systems (United Nations, 2019).

Unsurprisingly, therefore, the pressure that pension systems face has been researched in many contexts. An example is research by Li and Mérette (2005), who examine the effect of ageing on China's social security system, as well as economic well-being and living standards. They contend that the threefold increase in China's old-age population could have a detrimental effect on living standards. They compare several alternative scenarios where they alter the benefit rates, retirement age, and technological progress. They find that it is possible to maintain living standards for both workers and retirees by having a combined reform on all three fronts. Namely, reducing the benefit rates, increasing the retirement age from 60 to 65, and sustaining total factor productivity growth increases the potential for GDP growth, among other things, which will ensure stable living standards for all age groups. This, however, may prove difficult in China's political environment. Similar research is done by Blake and Mayhew (2006), but they consider the United Kingdom. They, too, simulate a model where they alter key concepts, such as pension age, contribution rates and economic activity rates. With immigration not truly being a viable solution to revitalise the pension system (see Coleman, 2002), they search for alternative solutions. They find that continued economic growth and other economic contributions from the current working-age generation, such as cuts in real pensions or contributing more while working, can greatly aid the situation. Another example is research by Lisenkova and Bornukova (2017), who examine the generous pay-as-you-go pension system in Belarus. They show that ageing and the generosity of the system make it unsustainable, and continue by estimating the effects of several reforms, including those that started in 2017. They find that both a reduction of pension benefits as well as an increase in the retirement age to 65 for both genders will make the system much more sustainable.

Related to the effect of ageing on pension systems is the effect that ageing has on inequality. This effect has been widely researched, as a larger group of older persons relative to the working-age population has, as discussed above, often led to reduced coverage as well as lower adequacy of pension systems (United Nations, 2015). This in turn has the potential to widen inequality, both for developed as well as for developing countries (Deaton & Paxson, 1994; Wang et al., 2017). This same conclusion is drawn by Razin, Sadka and Swagel (2002), as they find that ageing leads to smaller social transfers, especially in democratic countries, despite the increasing weight that elderly have in voting.

Though pension systems and reduced labour income have often been put forward as channels through which inequality could increase in ageing populations, there is no real consensus (Wang et al., 2017). Wang et al. (2017) find that ageing is indeed positively associated with inequality, and is also negatively correlated with labour income. They narrow it down further by considering the two components of labour income, namely, employment and wage. Even though the relationship between age and wage is negative and insignificant, there is a negative and significant relationship between ageing and employment, indicating that reduced employment is the real driver of inequality (Wang et al. 2017).

Finally, much research has also been done on the effect of population ageing and opportunities for economic growth. In the first stage of population ageing, when ageing is driven by a decline in fertility, the growth of the working-age population compensates for population ageing. Namely, the number of young and old people decreases relative to the number of working-age people (Bengtsson, 2010). With the appropriate policies in place, there are considerable opportunities for economic growth. Therefore, this phenomenon of enhanced economic opportunity is termed the *demographic dividend* (Bloom, Canning & Sevilla, 2003). As the ageing process continues when fertility rates stabilise at low levels and old-age mortality rates decrease, however, the dividend turns into a *demographic burden*. Videlicet, the share of the elderly in the population rises, whereas a stable level of young persons is added to the population, and thus the dependency ratio rises (Bengtsson & Scott, 2010).

There are two channels through which ageing can have a detrimental effect on economic growth opportunities. Firstly, the decrease in labour supply hampers economic growth (Jafrin et al., 2021). Both consumption and, especially, production levels are age-specific (Bengtsson, 2010). As populations age, a larger share is in their non-productive retirement stage, leading to a reduction in labour-force participation (Lee, 1994). Bloom and Williamson (1998) research the economic miracle of East Asia, where the demographic transition resulted in a significant drop in the dependency ratio between 1965 and 1990. They find that the changing age structures towards younger ages are the vessel through which demography influences growth, as the labour force grows. Bloom et al. (2003) share these findings. In addition to arguing that a younger population has a larger labour supply, they also find that due to the demographic transition, family size declines, and more women enter the labour force, leading to further labour supply increases and economic growth. Like Bloom et al. (2003), Maestas et al. (2016) find that labour supply decreases as populations age and that this is an important channel of reduced growth opportunities. However, they find that this channel is not as important as another, namely the slower growth in labour productivity of workers further ahead in the age distribution. Bosworth, Bryant, and Burtless (2004) also reach the effects of population ageing, but they focus on developing countries. They, too, find that Europe and Japan experience a shrinking workforce due to population ageing and that this is why economic growth may be hampered.

Secondly, a decreased savings and investment rate in old age hampers economic growth. Bloom et al. (2003) and Jafrin et al. (2021) find that the dependent share of the population saves less than the working-age population, as people of working age tend to earn more than they consume. Furthermore, Bosworth et al. (2004) argue that there are reduced investment opportunities in ageing populations, and they find that this is indeed the case, as there will be fewer workers for which to provide equipment. This reduced investment opportunity in combination with lower savings and investment rates will have detrimental economic effects in ageing populations (Bloom et al., 2003; Jafrin et al., 2021).

2.2. Population Ageing and International Trade

From the previous sub-section, it becomes clear that population ageing thus has many detrimental economic effects. One of these effects is a reduced opportunity for economic growth. Economic growth relates very closely to another concept, namely that of international trade. Specifically, this well-established relationship between the two concepts is the reason that economic growth is so entrenched in the gravity model of international trade (Head & Mayer, 2014; Yotov et al. 2016). Considering the evidence that population ageing influences economic growth and that economic growth influences trade, it would only make sense for there to be an effect of ageing on international trade (Tian et al., 2011). Still, there is an extreme lack of research on this link. The research that does exist, however, focuses on trade-related subjects, such as comparative advantage and trade openness. These could be considered the channels through which population ageing might influence international trade.

Firstly, some research has been done on how demographic change influences countries' comparative advantage (World Trade Organization, 2013). Cai and Stoyanov (2016) highlight that variations in demographic structure between countries serve as sources for comparative advantage in trade. They go deeper than merely labour supply and argue that changes in population age structure affect the relative supply and price of skills, since skills are age dependent. When countries then experience an increase in the age of their labour force, they will gain a comparative advantage in industries in which the older group is more efficient, resulting in higher exports for that industry (Cai & Stoyanov, 2016). This is similar to the Rybczynski (1955) theorem, which posits that as a factor of production expands, the industry that uses it relatively intensively will see a more than proportional increase in output, whereas the industry that does not use it intensively will see its output decline. Contrastingly, Gu and

Stoyanov (2019) explore the loss of competitive advantage as populations age. Namely, as a person ages, their ability to keep their skills up to date decreases. An ageing population can then experience a loss in comparative advantage in industries that require up-to-date skills, reducing exports for that industry (Gu & Stoyanov, 2019).

Secondly, there has also been some research on the influence of a population's age structure on capital flows and the trade balance (World Trade Organization, 2013). Higgins (1998), for example, considers the effect of a population's age structure on aggregate savings and the current account balance. Like Bosworth et al. (2004), he finds that a younger population will have a low savings rate as the dependency burden is high, and an investment rate that starts to increase as more people become of working age. As a result, an ageing, open economy will have a current account deficit; a lot of capital flows into the country due to the investment opportunities, as the lack of own capital prevents them from seizing that opportunity (Higgins, 1998).

Thirdly, another important part of the literature is the research on the link between a population's age structure and *trade openness*, the ratio of trade to GDP. Fukumoto and Kinugasa (2017) explored this link, hypothesising that dependants consume more non-tradable goods, and that working-age persons consume more tradable goods. Their findings indeed reflect this assumption of age-dependent preferences for tradable and non-tradable goods; ageing populations have reduced trade openness. Building upon this, Fukumoto and Kinugasa (2021) analyse different regions in the world to see whether this hypothesis holds, and they indeed find evidence for this link in all regions but Africa.

These are some examples of trade-related subjects that are influenced by a population's age structure. This points to a significant influence of age structure on trade, even though the research on this relationship directly is very sparse.

Namely, the only paper that truly focuses on international trade and age structures is that of Tian et al. (2011). With a panel dataset, containing 176 countries between 1970 and 2006, they estimate a gravity model augmented with demographic dependency ratios to gauge whether a population's age structure influences its bilateral trade. They hypothesise two channels through which this influence may arise. Firstly, the scale effect suggests a low dependency ratio of an exporter enables production and thus increased exports, as the labour force grows. On the importer side, the low dependency ratio and larger labour force lead to higher income, and therefore, increased imports. Secondly, the structural effect suggests that export compositions change relative to the factor endowments of the country. A relatively young population, which is labour abundant, will be able to export more labour-intensive products, whereas a capital-abundant country with an ageing population will experience an increase in the capital-labour intensity, and thus export more capital-intensive products (Tian et al., 2011). This, too, is in line with the Rybczynski (1955) theorem and the line of thought by Cai and Stoyanov (2016). With their gravity model, Tian et al. (2011) find support for both effects, thus deeming the age structure of a population important in determining bilateral trade.

As becomes clear from the previous discussion, there is a clear effect of a population's age structure and international trade. However, the only paper that directly considers the effect of age structure on international trade levels is that of Tian et al. (2011). This relation is strongly overlooked in the literature, and therefore, this thesis shall attempt to shed light on it. I hypothesise that age structure, captured with old-age demographic dependency ratios, will affect trade. As the view of the importer is, in the sparse literature that does exist, mostly disregarded, it will have a more central role in this thesis. In line with Fukumoto and Kinugasa (2017), I hypothesise that the non-working age population has a tendency to consume more non-tradable goods, and, in line with Tian et al. (2011), that the non-working age population generates lower incomes to fund their consumption. Therefore, I hypothesise that as the dependency ratio of the importer increases and thus the population ages, bilateral trade will decrease. My first hypothesis can thus be phrased as follows:

> *H1: "Bilateral trade decreases as the old-age demographic dependency ratio of the importer increases."*

This hypothesis, though, has already been confirmed in the research of Tian et al. (2011). However, a piece of criticism of their research is that they utilise a rather narrow specification of the gravity model of international trade. Several variables that are essential in the gravity model, according to Head and Mayer (2014), are missing. Examples of this are GDP, whether countries are contiguous, in essence, whether they share a border, and whether they have a regional trade agreement (RTA) at that time. Given that these are factors that need to be controlled for, as their effect has been proven in countless other gravity model estimations, the true effect of population ageing becomes difficult to disentangle (Spector & Brannink, 2011). Therefore, to accurately estimate the effect of population ageing on international trade, this thesis will estimate a gravity model that takes all the important gravity-model variables into account and is thus a more widely accepted specification.

2.3. Population Ageing and Life Cycle Theory

Though it already becomes clear from the above discussion that population ageing is not without repercussions, it is often said that the actual extent to which population ageing is of influence on the economy depends on age-specific patterns of production and consumption (United Nations, 2019). For this reason, as well as the fact that consumption is proven to affect trade, consumption needs to be considered in determining the effect of population ageing on international trade (World Trade Organization, 2013). Specifically, changes in the age structure of a population can influence the level, as well as the composition of consumption (Aigner-Walder & Döring, 2012; Bengtsson, 2010; World Trade Organization, 2013). For example, after retirement, private consumption declines (see for example Battistin, Brugiavini, Rettore & Weber, 2009; Haider & Stephens Jr., 2007), whereas public consumption, constituting consumption of health care, for example, increases steeply (see for example Lee & Mason, 2011a). Thus, as populations age, the aggregate level of private consumption decreases. This is referred to as the retirement-consumption puzzle (Lefèbvre, 2006; World Trade Organization, 2013). This is then likely to impact trade flows, as the composition of import demand changes. To understand how this ageing and consumption affect trade, it is useful to first consider the theory, as well as the literature on life-cycle trends of consumption (World Trade Organization, 2013).

An important theory that links consumption to ageing is the consumption life-cycle theory, also termed the life-cycle hypothesis (Modigliani & Brumberg, 1954; Modigliani & Brumberg, 1990). Modigliani and Brumberg (1954; 1990) formulated the life-cycle hypothesis, and they theorise that individuals prefer to smooth their lifetime consumption patterns. Therefore, individuals can save when they are of working age as their income exceeds their consumption, and then they expend those savings when they enter retirement as consumption exceeds income (Modigliani & Brumberg, 1954; 1990).

At the time of formulating this hypothesis, however, empirical analysis was not possible. Therefore, by now, the theory has gained empirical support but has also been contested on several accounts (Deaton, 2005; World Trade Organization, 2013). An example of such criticism is how savings are not as rapidly expended by the elderly as assumed, since elderly persons are motivated to keep some of those savings for bequests or precaution in the case of an unexpected health or economic shock. However, each of those pieces of criticism has been carefully rebutted, and the consumption life-cycle theory remains an influential theory that allows for the estimation of how consumption influences many important societal aspects, such as pensions and living standards (Deaton, 2005).

Unsurprisingly, much research has been done concerning population ageing and the life-cycle hypothesis. An example is the research of Aigner-Walder and Döring (2012). They contend that both the level as well as the composition of private consumption changes with the age structure of the population, following the life-cycle hypothesis. They use Austrian household-level data and find support for this. Furthermore, they use these results to make inferences about the future, as Austria is experiencing severe population ageing, to determine which consumption categories will see their shares increase. They find that there will be a decrease in the consumption of transport goods, whereas there will be increased consumption expenditures for housing, water, electricity, gas, and other fuels, as well as for food and non-alcoholic beverages (Aigner-Walder & Döring, 2012).

A similar analysis is executed by Stöver (2012), but she considers Germany. By including age-group coefficients for eight different age groups in her estimation, she attempts to estimate how consumption changes for every age group. With this, she draws inferences on the effects of population ageing on different consumption categories. She finds that food and non-alcoholic beverage consumption expenditures decrease as populations age, whereas health consumption expenditures increase as populations age (Stöver, 2012).

A final example of research that estimates the effect of population ageing on consumption is that of Lefèbvre (2006). He performs a similar study to those of Aigner-Walder and Döring (2012) and Stöver (2012) but considers Belgium. He, too, argues that consumption expenditures change over the life cycle, and thus the level and structure of aggregate consumption will change as Belgium's population ages. Like Aigner-Walder and Döring (2012) he uses household survey data to estimate the effect of age on expenditures of several consumption categories, and then forecasts consumption composition until 2050. Lefèbvre (2006) also finds that expenditures in health, housing and leisure increase, whereas those in equipment, clothing, and transport decrease.

All these studies on consumption life-cycle theory demonstrate that the population's age composition is a non-negligible factor when considering consumption. Ageing thus clearly influences both the level of consumption, as well as the composition of this consumption (Stöver, 2012). It thus comes as no surprise that this alters import demand (World Trade Organization, 2013). However, analyses that directly incorporate population ageing, consumption, and international trade are lacking. As one can reasonably expect there to be an influence between the three factors, this thesis shall attempt to establish this effect to fill the gap in the literature.

To that end, *consumption ratios* shall be calculated. These ratios function similarly to demographic dependency ratios, in that they consider changing population age structures. However, instead of solely considering the age structure, consumption ratios also take the changing private consumption levels of different age groups into account. Their calculation shall be further elaborated upon in Section 3. The following two hypotheses are proposed based on the discussion above:

H2: "Bilateral trade decreases as the consumption ratio of the importer increases."

H3: "Bilateral trade decreases (increases) in categories where the elderly are expected to consume relatively little (much), as the consumption ratio of the importer increases."

Hypothesis 2 is similar to hypothesis 1, however, it does not take demographic dependency ratios into account, but rather consumption ratios. Therefore, here, too, I expect to find a negative effect between population ageing and bilateral trade. I expect that, as individuals retire, their private consumption decreases, following the retirement-consumption puzzle. As the elderly share in the population grows, aggregate private consumption decreases, resulting in reduced import demand and thus a lower level of trade (World Trade Organization, 2013). Hypothesis 3 goes even more in-depth. Similar to the research by Aigner-Walder and Döring (2012), Lefèbvre (2006), and Stöver (2012), I then consider disaggregated trade. This is in an attempt to see whether, like consumption, we see trade categories increase or decrease as a result of population ageing. As contended by the above authors, not all consumption categories behave the same as a result of population ageing; some categories experience an increase as the population ages, whereas others experience a decrease (Aigner-Walder & Döring, 2012; Lefèbvre, 2006; Stöver, 2012). As the population ages, the consumption categories in which elderly persons expend more will gain greater weight in the aggregate consumption structure, and thus in import demand. Therefore, I expect to see that, as a result of an ageing population of the importer, trade in those categories increases, whereas trade in other categories decreases.

3. METHODOLOGY AND DATA

To research the effect of population ageing on international trade, a gravity model will be employed. The gravity model of international trade was pioneered by Tinbergen (1962). It is one of the first applications of Newton's Law of Universal Gravitation on economic principles. Over time, the model has gained a very robust theoretical foundation, which led to its wide application in trade research. It provides an excellent explanation for the level of bilateral trade between the exporting country, the *origin*, and the importing country, the *destination* (Yotov et al., 2016). This makes it incredibly suitable for the analysis in this thesis.

In its simplest form, the gravity model of international trade shows that bilateral trade increases with economic size, measured through gross domestic product (GDP), of both the exporting and importing countries, and decreases with a higher distance, which functions as a proxy for trade costs, between the two countries (Tinbergen, 1962; Yotov et al., 2016). The gravity model utilised in this thesis shall be based on that of Tian et al. (2011), however, it shall be an extended version, such that it accounts for missing but required control variables (Head & Mayer, 2014; Spector & Brannick, 2011).

This section provides the basis upon which the analysis of this thesis will be executed. Firstly, the methodology is considered, where the gravity model applicable to this thesis is explained a little more elaborately, after which the different estimation techniques will be highlighted. To correctly estimate the gravity model, many techniques are possible, each with its advantages and disadvantages, and the choice of estimation techniques in this thesis will be elaborated upon. Secondly, the data used to estimate the gravity model is explained. I discuss the data used in the baseline estimations, as well as the data used for the sensitivity analyses and the disaggregated analyses. I also shed light on the regression assumption checks that are completed before the start of the analyses. Note, that as parts of the model and the data used are similar to my earlier work, there is some degree of overlap (Meijer, 2022). The approach is not wholly the same, though, as I take an importer-centred view in this thesis, and add the NTA approach by considering the effect of consumption in combination with ageing on trade.

3.1. Methodology

3.1.1. The gravity model of international trade

In the gravity model of international trade, the dependent variable is *bilateral trade* between the origin and the destination at time *t*. The independent variables for the estimations in this thesis are the old-age demographic *dependency ratio of the importer*, the *consumption ratio of the importer*, the *GDP of the exporter*, the *GDP of the importer*, and the *distance* between the exporter and importer.

For the initial models, the *dependency ratio of the importer* is the measure that captures the population age structure of the importer. Following hypothesis 1, I expect to find a significant negative coefficient for this variable. Namely, as the population ages, the age group that generates lower incomes and that consumes relatively more non-tradable goods increases in size, which will lead to a reduction in trade (Fukumoto & Kinugasa, 2017; Tian et al., 2011).

GDP of the exporter and *GDP of the importer* are measures of the economic size of the country. These two variables are part of the 'typical gravity variables'-list provided by Head and Mayer (2014) and are proxies for the economic size of the trading partners. Bilateral trade increases with economic size, and therefore, I expect the coefficients of both these variables to be significant and positive (Head & Mayer, 2014; Shepherd, 2012; Tinbergen, 1962).

Another variable that is part of the 'typical gravity variables'-list, is *distance* between the exporter and importer. Distance serves as a proxy for trade costs, as these are often difficult to estimate (Yotov et al., 2016). Higher costs and thus a larger distance hampers trade, and, therefore, I expect trade to decrease with distance; the coefficient of distance is expected to be significant and negative (Head & Mayer, 2014; Shepherd, 2012; Tinbergen, 1962). The importance of distance has of course decreased in recent years, as countries become more interconnected. Therefore, I expect the size of the coefficient to become smaller when introducing time-fixed effects, as these fixed effects pick this difference up.

The other control variables added to the model are those of whether the countries have *contiguity* and thus whether they share a border, whether they have a *common official language*, whether they have ever had a *colonial or dependency relationship*, whether they have ever had a *sibling relationship*, whether they are *both GATT or WTO members* at that time, whether they are *both EU members* at that time, and whether they share a *regional trade agreement (RTA)* at that time. These control variables are thus bilateral, in the sense that they utilise information from both countries at the same time, and are taken from the 'typical gravity variables'-list of Head and Mayer (2014). All these variables, like *distance*, represent trade costs. Trade costs are very important in determining trade levels, as they have the distinct ability to reduce the level of trade both economically as well as statistically significantly (Anderson & Van Wincoop, 2004). For each of these variables, it holds that if they are true, so if they for example do share a common official language, trade is enabled. Therefore, for each of these control variables, I expect to find a positive and significant relationship to bilateral trade (Anderson &

Van Wincoop, 2004; Head, Mayer & Ries, 2010; Tian et al., 2011). The model is then as follows:

$$(1)\ \ln bilateral\ trade_{odt} = \beta_0 + \beta_1 \ln dependency\ ratio\ of\ the\ importer_{dt} + \beta_2 \ln GDP\ of\ the\ exporter_{ot} + \beta_3 \ln GDP\ of\ the\ importer_{dt} + \beta_4 \ln distance_{od} + \beta_5\ contiguity_{od} + \beta_6\ common\ official\ language_{odt} + \beta_7\ colonial\ or\ dependency\ relationship_{odt} + \beta_8\ sibling\ relationship_{odt} + \beta_9\ both\ GATT/WTO\ members_{odt} + \beta_{10}\ both\ EU\ members_{odt} + \beta_{11}\ RTA_{odt} + e_{odt}$$

The subscript *o* refers to the exporting country, or the *origin* country. The subscript *d* refers to the importing country, or the *destination* country. The subscript *t* refers to the time dimension. The most intuitive version of the gravity model, which is also the most-used version, is the log-linearised form. Therefore, this thesis shall also consider the log-linearised form of the model (Shepherd, 2012; Yotov et al., 2016). The model shall be estimated incrementally. As such, I start with the most reduced version, using only the GDP and distance variables as determinants of bilateral trade. For every estimation, I add variables incrementally, to see whether the new variables pick up any effects (Shepherd, 2012).

The aim of this research, however, is to not only incorporate the effect of ageing populations, but its contribution is twofold, as the aim is to also include the changing consumption habits of these populations. Therefore, instead of using the demographic old-age dependency ratios, which only capture age, I also estimate the model with the consumption ratios of the importer. Like the *dependency ratio of the importer*, the *consumption ratio of the importer* captures the population age structure, however, it also considers the changing private consumption pattern throughout the life cycle. Therefore, I expect to find a negative coefficient, conform with hypothesis 2, as older individuals consume less, and when their group grows relative to the rest of the population as the population ages, trade will decrease (World Trade Organization, 2013). The second form in which the model is estimated is then as follows:

$$(2)\ \ln bilateral\ trade_{odt} = \beta_0 + \beta_1 \ln consumption\ ratio\ of\ the\ importer_{dt} + \beta_2 \ln GDP\ of\ the\ exporter_{ot} + \beta_3 \ln GDP\ of\ the\ importer_{dt} + \beta_4 \ln distance_{od} + \beta_5\ contiguity_{od} + \beta_6\ common\ official\ language_{odt} + \beta_7\ colonial\ or\ dependency\ relationship_{odt} + \beta_8\ sibling\ relationship_{odt} + \beta_9\ both\ GATT/WTO\ members_{odt} + \beta_{10}\ both\ EU\ members_{odt} + \beta_{11}\ RTA_{odt} + e_{odt}$$

Here, too, the subscript *o* refers to the exporting country, or the *origin* country. The subscript *d* refers to the importing country, or the *destination* country. The subscript *t* refers to the time dimension.

To further disentangle the effect of both population ageing and changing consumption patterns, the second model shall also be estimated with disaggregated versions of bilateral trade. The variables shall be based on several Standard International Trade Classification (SITC) sectors, but their composition shall be further highlighted in Section 3.2. Thirteen of such sectors will be utilised, and therefore, the following model will be estimated thirteen times, each with a different dependent variable for bilateral trade:

$$(3)\ \ln bilateral\ trade\ in\ sector\ \mathrm{i}_{odt} = \beta_0 + \beta_1 \ln consumption\ ratio\ of\ the\ importer_{dt} + \beta_2 \ln GDP\ of\ the\ exporter_{ot} + \beta_3 \ln GDP\ of\ the\ importer_{dt} + \beta_4 \ln distance_{od} + \beta_5\ contiguity_{od} + \beta_6\ common\ official\ language_{odt} + \beta_7\ colonial\ or\ dependency\ relationship_{odt} + \beta_8\ sibling\ relationship_{odt} + \beta_9\ both\ GATT/WTO\ members_{odt} + \beta_{10}\ both\ EU\ members_{odt} + \beta_{11}\ RTA_{odt} + e_{odt}$$

Again, the subscript *o* refers to the exporting country, or the *origin* country. The subscript *d* refers to the importing country, or the *destination* country. The subscript *t* refers to the time dimension.

3.1.2. Econometric challenges and estimation techniques

A known fact about gravity models is that their estimation is plagued by econometric problems. However, their widespread use in research and their sound theoretical base have also brought about many solutions. This sub-section is devoted to a brief discussion of these econometric problems, as well as which estimation techniques are suited to address them. The estimation techniques that are possible for gravity models, and that help in combating these econometric problems, include pooled OLS regression, fixed-effects regressions, which can take many forms, and Poisson Pseudo-Maximum Likelihood (PPML) estimations with or without fixed effects (Head & Mayer, 2014; Shepherd, 2012; Yotov et al., 2016). I will conclude this sub-section by explaining the estimation techniques used in this research.

The first econometric challenge is the issue of zero trade flows. This issue occurs specifically in the log-linearised version of the gravity model. Namely, when the variables are transformed into their logarithmic forms, observations where the trade flow takes a value of zero are dropped from the sample. The typical solution for this is to use a PPML estimation technique, since it allows for trade to be used in its multiplicative form (Shepherd, 2012; Yotov et al., 2016). For this reason, the gravity models in this analysis will also be estimated using a PPML estimator.

The second econometric challenge is heteroskedasticity. As will be explained in Section 3.2, trade data is generally very heteroskedastic, resulting in biased and inconsistent estimations when estimating the model in its multiplicative form. Therefore, a typical solution for this is again to use the PPML estimator, as it allows for the avoidance of the multiplicative form.

Furthermore, the use of robust standard errors also reduces heteroskedasticity. In the analyses, the standard errors are also clustered on distance, so that each pair of trading partners is uniquely identified to allow for correlation of the error term (Shepherd, 2012; Yotov et al., 2016).

The third econometric challenge arises because of the multilateral resistance terms. Multilateral trade resistance refers to trade barriers that every country faces with all its trading partners. These terms are mostly theoretical constructs, which are difficult to estimate as they are mostly unobservable (Adam & Cobham, 2007; Yotov et al., 2016). For example, trade between France and Italy is also dependent on how costly it is for both to trade with other countries. As the trade costs between France and the United Kingdom decline, the multilateral trade resistance of France will decrease, as it becomes less costly to trade with another country (Adam & Cobham, 2007). To control for multilateral trade resistance, exporter-fixed effects and importer-fixed effects will be used. These exporter- and importer-fixed effects also control for country-specific characteristics that are not included in the other variables, as well as the country's overall level of trade. With their inclusion, I thus expect the coefficients to change in size, as I then no longer assume coefficients to be the same for every importer or exporter. I also expect the intercepts to decrease, as all individual heterogeneity of the importers and exporters is no longer captured in the intercept, but in the fixed effects. In a similar manner, time-fixed effects are also introduced, which control for economic shocks that all countries experience in that year (Adam & Cobham, 2007; Feenstra, 2016; Hummels, 2001; Yotov et al., 2016).

The final econometric challenge can be found in the endogeneity concerns that arise when estimating the gravity model. For example, issues of reverse causality can easily arise in gravity models, but may be solved through the use of interval data, and by including multiple types of fixed effects. Another endogeneity issue is omitted variable bias, but a considerable share of this issue can be resolved through the use of fixed effects, as time-invariant omitted variables can, for example, be subsumed into the fixed effects (Shepherd, 2012; Yotov et al., 2016).

Thus, four main econometric challenges arise in the estimation of gravity models. Zero-level trade flows, heteroskedasticity, multilateral resistance terms, and endogeneity concerns may result in the inaccurate estimation of the model. However, as the above discussion proves, many of these concerns can be, at least partially, addressed through the use of different types of estimation techniques. To that end, a (pooled) OLS regression model will be estimated, as well as a model with time-fixed effects, and a model with both time and exporter- and importer-fixed effects, all with robust clustered standard errors. The combination of these models already results in a very robust estimation (Yotov et al., 2016). Even though the use of multiple types of fixed effects and robust clustered standard errors already solves most of these econometric issues, PPML models are also estimated to account for zero trade flows, and can be found in the appendices. A PPML model with fixed effects was also estimated, as well as a regression model with exporter-time and importer-time fixed effects, however, all important variables are subsumed into these fixed effects, and as they can thus not be interpreted, they will not be included in the results.

3.2. Data

After having elaborated upon the econometric issues and methods, I now turn to a discussion of the data used for the estimation of the effect of ageing on international trade. In this research, three datasets are used. The first dataset, used for the baseline estimations, only considers gravity variables at the aggregated country level. This is also true for the second dataset, which is used for the sensitivity analyses. The third dataset is highly similar to the second, but considers industry-level trade data. This sub-section highlights the characteristics of all datasets. All variables, as well as their explanations and sources are also combined in a list, which can be found in Appendix A (see also Meijer, 2022).

3.2.1. NTA gravity dataset used for baseline analyses

The first dataset used to estimate the models that were put forward in the previous sub-section is a large panel dataset with gaps. The years included range from 1981-2019, and contain data from 66 importing countries, and 199 exporting countries. The sample of importing countries consists of all countries for which data is available in the National Transfer Accounts (NTA) database. The data from this database is used to calculate the consumption ratios. As data for the consumption ratios were not available for all 66 countries in all years, as many years as possible are included in the sample. This does mean, however, that there is high variability in the years included. To keep the sample as constant as possible, data for the analyses with old-age demographic dependency ratios is gathered only for these importing countries in their respective years. A list of the importing countries included, and their respective years, can be found in Appendix B. Initially, the dataset included 248 exporting countries, however, as for many countries the data quality and availability were low, these countries were dropped from the sample. Countries that were dropped include small island nations, city-states, or territories that were accounted for by being included in other territories. A few examples of such instances are the Faroe Islands, the Cook Islands, and Monaco. After this correction, the dataset contains 31,044 observations, each consisting of a combination of one of the 66 importing countries, and one of the 199 exporting countries, in a certain year.

The data for the gravity model variables are obtained from the CEPII Gravity Database (Head & Mayer, 2014). This database is widely used, as it contains data to estimate gravity equations for any country pair between the years 1948 and 2019. The data is compiled from a wide array of sources, as will now be described. For the dependent variable *bilateral trade,* importer-reported data from the IMF were used. Importer-reported data are often deemed more accurate than exporter-reported data, as importers have incentives to correctly report data for example to ensure the correct income earned from tariffs. The data is divided by the CPI to obtain real values (Eurostat, 2023b; OECD, 2023; World Bank, 2023a). Following the discussion in the previous sub-section, the data for *bilateral trade* was transformed into its logarithmic form in all non-PPML estimations, as it is used in its multiplicative form in those.

Data for both *GDP* variables were obtained from the World Bank's Development Indicators (WDI) and are also divided by the CPI to obtain real values (Eurostat, 2023b; OECD, 2023; World Bank, 2023a; World Bank, 2023b). This data was also log-transformed, as it allows for a more straightforward interpretation of the coefficients.

Data for the *distance*, the *contiguity*, and the presence of a *common official language* between the origin and destination countries, were derived from the CEPII GeoDist Database (Mayer & Zignago, 2011). The *distance* is as measured between the capitals of the two trading partners, and is also log-transformed following literature. This transformation, however, results in more skewed data. When performing the estimations, a check is done where *distance* is used in the model in its multiplicative form, however, the difference in results is very limited (see also Meijer, 2022). *Contiguity* is a dummy variable equal to 1 when the two trading partners are contingent and thus share a border. *Common official language* is also a dummy variable, which takes a value of 1 when the two trading partners share an (official) language.

Data for the *colonial or dependency relationship* and whether there has ever been a *sibling relationship* between the trading partners is taken from the Colonial Ties Dataset (Head, Mayer & Ries, 2010). Both these variables are dummy variables that take a value of 1 when the trading partners have ever been in such a relationship.

Finally, three dummies represent trade agreements or similar institutions, namely whether the trading partners are *both GATT/WTO members*, whether they are *both EU members,* and whether they have an *RTA* at that time. *Both GATT/WTO members* was compiled from four variables in the CEPII Gravity Database. Initially, they were unilateral variables, where there was a variable for exporter membership of the GATT, one for importer membership of the GATT, one for exporter membership of the WTO, and one for importer membership of the WTO. The information from these variables was used to create one bilateral variable, which takes a value of 1 when both the trading partners are a member of the GATT or the WTO at that point. The same was done for *both EU members*; it, too, was compiled based on two unilateral variables indicating membership of the exporter and importer separately. This variable also takes a value of 1 if both trading partners are EU members at that point. The variable for the presence of an *RTA* also takes a value of 1 if the trading partners are in a regional trade agreement at that point (Head & Mayer, 2014).

In the category of the population age structure variables, there are two groups. The first group consists of the old-age demographic dependency ratios. The dependency ratios are used in the estimation to determine the effect of population ageing on international trade, without regard for changing consumption patterns. The dependency ratios are calculated based on data from the United Nations World Population Prospects (United Nations, 2022). The UN provides data of one-year age groups, separate for every sex or a total, which allows for the calculations of dependency ratios for the same age groups as for the consumption ratios. The dependency ratios are constructed as the number of people in a certain age group, relative to the number of people of working age, i.e., those in the ages of 20 to 64. Using the total data for every one-year age group, the totals for different age groups are calculated. For example, the dependency ratio for ages 65-69 is calculated as the number of people aged 65-69, relative to the number of people aged 20-64. The baseline model includes only the 65+ dependency ratio, however, for comparability to the consumption ratio models, and to extract additional information, this age group is split. The age groups for which the ratios are calculated are 65+, 65-69, 70+, 70-74, 75-79, and 80+, and are used in a variety of combinations in the estimations.

The second group consists of the consumption ratios. The consumption ratios are calculated based on private consumption data from the NTA database (Lee & Mason, 2011b). The NTA project aims to construct data that can help in understanding how population growth and changing population age structures influence constructs such as pensions, economic growth, the contribution of women, and public finances, among others (Lee & Mason, 2011b).

Consumption ratios are constructed to capture not only the changing population age structure, as when populations age, older age groups grow relative to younger age groups in the population, but also the changing consumption pattern at older ages. They thus contain more information than the dependency ratios. For example, Italy has an old-age 65+ dependency ratio of 0.33 in 2008, whereas its 65+ consumption ratio is lower at a value of 0.22 in that year. The consumption ratio takes the age structure into account, but also demonstrates that the elderly consume less, reducing the ratio. An elaborate discussion of this is provided in Sections 2.1 and 2.3. The NTA database provides data on the aggregate private consumption level for every one-year age group. It should be noted, however, that the data on consumption is not as accurate as their data on income. Namely, the NTA income data is based on income tax reports, for example, whereas consumption data is based mostly on surveys (Lee & Mason, 2011a; Lee & Mason, 2011b). This may reduce the accuracy of the consumption ratios. The consumption ratios are constructed as the private consumption of the relevant age group, relative to the private consumption of the total population. The age groups for which the ratios are calculated are again 65+, 65-69, 70+, 70-74, 75-79, and 80+. For example, the consumption ratio of ages 65-69 is calculated as the aggregate consumption of everyone in this age group, divided by the aggregate consumption of everyone in the population. The baseline model includes only the 65+ consumption ratio. However, as even after age 65, consumption patterns still change, splitting this age group up provides more information. To that end, consumption ratios for the five-year age groups, the 70+ age group, and the 80+ age group are estimated. The models will be estimated with a wide variety of combinations, to gain as much information as possible from these ratios.

The descriptive statistics for this dataset are shown in Table 1. Of note is that for all continuous variables, normality is approached. The skewness is in all instances relatively close to zero, and the kurtosis relatively close to three. This cannot be said for distance. However, as mentioned above, using the multiplicative form of distance does not change the results of the estimations notably. It is also important to note that there is quite a high variability in some cases, for example when looking at *bilateral trade*, *GDP of the exporter,* and *GDP of the importer*. This, however, is easily explained by the high diversity of the countries present in the dataset.

Table 1. Descriptive statistics NTA gravity dataset

Variables	Obs.	Mean	Std. Dev.	Min	Max	Skew.	Kurt.
Log of Aggregate Bilateral Trade	23895	4.8736	4.444	-11.5117	15.2965	-.407	2.7255
Log of 65+ Consumption Ratio Importer	31044	-2.3826	.6535	-3.7107	-1.4036	-.3559	1.7498
Log of 65-69 Consumption Ratio Importer	31044	-3.4691	.5022	-4.6448	-2.5935	-.4478	1.952
Log of 70+ Consumption Ratio Importer	31044	-2.8084	.741	-4.3384	-1.7122	-.3388	1.7635
Log of 70-74 Consumption Ratio Importer	31044	-3.731	.5871	-5.1412	-2.7385	-.4461	1.9222
Log of 75-79 Consumption Ratio Importer	31044	-4.075	.7323	-5.8958	-2.9837	-.4432	1.9173
Log of 80+ Consumption Ratio Importer	30845	-3.9996	.9851	-6.3823	-2.3639	-.3398	1.9962
Log of 65+ Dependency Ratio Importer	31044	-1.9427	.5177	-3.0171	-1.096	-.2764	1.7215
Log of 65-69 Dependency Ratio Importer	31044	-3.0184	.3945	-3.9081	-2.2457	-.3426	1.904
Log of 70+ Dependency Ratio Importer	31044	-2.3691	.5891	-3.6015	-1.4199	-.2721	1.7116
Log of 70-74 Dependency Ratio Importer	31044	-3.2726	.4692	-4.3106	-2.4279	-.2756	1.7617
Log of 75-79 Dependency Ratio Importer	31044	-3.6064	.5836	-4.8418	-2.6718	-.2782	1.7291
Log of 80+ Dependency Ratio Importer	31044	-3.5989	.7917	-5.2643	-2.3515	-.3333	1.8454
Log of GDP Exporter	28078	12.4807	2.3401	6.0978	19.1073	.1607	2.5706
Log of GDP Importer	31044	15.0513	2.6086	7.9078	18.9245	-.3435	2.3687
Log of Distance	30006	8.8494	.7461	1.8707	9.901	-1.7728	7.8863
Contiguity Dummy	29789	.0186	.135	0	1	7.1335	51.8869
Common Language Dummy	30006	.1496	.3567	0	1	1.9651	4.8617
Colonial or Dependency Relations	30463	.0156	.1239	0	1	7.8197	62.1485
Sibling Relationship Dummy	30463	.1979	.3984	0	1	1.5164	3.2995
Both GATT/WTO Member Dummy	31044	.6756	.4681	0	1	-.7503	1.5629
Both EU Member Dummy	31044	.0173	.1304	0	1	7.4046	55.8277
RTA Dummy	30474	.1139	.3177	0	1	2.4312	6.9106

Notes: This table depicts the descriptive statistics of the first gravity dataset, of which the sample is based on the NTA database. This dataset covers the years 1981-2019, with 66 importing countries and 199 exporting countries. Shown in this table are the number of observations, the mean, the standard deviation, the minimum, the maximum, the skewness, and the kurtosis for each variable.

An important step before turning to the analyses is determining if the regression assumptions are satisfied. Firstly, I check for the presence of heteroscedastic errors. After checking the data visually by plotting the residuals of the regression against the fitted values, it becomes clear that there is indeed a high level of heteroskedasticity, which is confirmed by the modified Wald test for groupwise heteroskedasticity. The null hypothesis of this test is a constant variance for all cross-sectional units, which is rejected with a Chi-squared value of 6.0e+8 (p-value = 0.0000) (Baum, 2000). As mentioned in Section 3.1, the PPML estimator and the use of robust standard errors address heteroskedastic errors (Head & Mayer, 2014; Shepherd, 2012).

Secondly, I test for the presence of multicollinearity. I find relatively high correlations between the four old-age demographic dependency ratios, and the four consumption ratios (age categories 65-69, 70-74, 75-79, and 80+) when they are present in the same model. For example, between the *65-69 consumption* ratio and the *70-74 consumption ratio*, the correlation coefficient takes a value of $\rho = -0.65$. To formally check whether any action is required against these multicollinearity levels, the Variance Inflation Factor is checked against a value of 10 (Hair, Anders, Tatham, & Black, 1995). If the VIF is higher than the threshold value, action has to be taken. The VIF reaches very high levels when all consumption or dependency ratios are entered in the same model, and therefore, several shall be omitted; not much information is lost if they correlate so highly. They shall therefore be entered in separate models, in a variety of combinations.

Finally, I check for the presence of serial correlation. The Woolridge test for serial correlation in panel data performs a Wald test, with the null hypothesis that there is no first-order autocorrelation (Woolridge, 2001). The null hypothesis is rejected (F = 72.576, p-value

= 0.0000) and thus there is first-order autocorrelation in the data. However, this can be aided by opting for clustered standard errors (Cameron & Miller, 2015).

3.2.2. AGENTA gravity dataset used for sensitivity analyses

The second dataset, used for the sensitivity estimations in this thesis, is a large cross-sectional dataset. The dataset contains data for the year 2010, for 25 importing countries, and again 199 exporting countries. The year 2010 was chosen as that was the only year for which data for the consumption ratios was available. Therefore, this sample, too, is based on all importing countries for which data is available in the European National Transfer Accounts (AGENTA) database. Again, this data is used to calculate the consumption ratios, and to keep the sample as constant as possible, data for the old-age demographic dependency ratios is also only gathered for these importers in 2010. A list of all included importing countries can be found in Appendix C. Here, too, the dataset initially included 248 exporting countries, however, the same instances (i.e., small island nations, city-states, and territories that were otherwise accounted for) were dropped from the sample, leaving 199 exporting countries. After this correction, the dataset contains 4,975 observations, where each observation is a combination of one of the 25 importing countries and one of the 199 exporting countries in 2010.

The gravity-model variables for this dataset are the same as those obtained and calculated for the NTA gravity dataset, as explained in Section 3.2.1 (Head & Mayer, 2014). The old-age demographic dependency ratios are also calculated in the same way as for the NTA gravity dataset, and based on the same UN data (United Nations, 2022). The big difference, however, between the datasets is the source of the data for the consumption ratios. Specifically, for this dataset, the data is obtained from the AGENTA database. The AGENTA project is a European version of the NTA project and aims at supplying data to accurately estimate age-specific economic behaviour (Istenič et al., 2016).

The AGENTA database supplies data in per capita terms. Therefore, to calculate the consumption ratios, first, all the private consumption levels of the age groups will be calculated. The same age groups as in the NTA gravity dataset are used, namely, 65+, 65-69, 70+, 70-74, 75-79, and 80+, as this allows for comparability to the NTA results, as well as the estimation of a wide variety of models. After calculating the levels of private consumption for each of the age groups, the levels are multiplied by the size of each relevant age group, based on data from the United Nations World Population Prospects (United Nations, 2022). The same is done for aggregate private consumption, of all ages, which is multiplied by the entire population. Finally, the consumption ratios are calculated, again, as the consumption level of the relevant age group relative to the entire consumption level of the population, similar to the NTA gravity dataset.

The descriptive statistics of the AGENTA gravity dataset can be found in Table 2. We again see that many continuous variables approach normality, but that the variability is in most instances smaller than in the NTA gravity dataset, especially in the case of the importer-characteristic variables, as we consider only European countries in this dataset, which are much more similar to one another than if we compare a developed to a developing country. For example, we see that the 65+ consumption ratio has a larger mean here, but that the variability is much smaller than for the NTA gravity dataset.

Table 2. Descriptive statistics AGENTA gravity dataset

Variables	Obs.	Mean	Std. Dev.	Min	Max	Skew.	Kurt.
Log of Bilateral Trade	4296	4.3279	4.4552	-10.7364	13.9361	-.4447	2.6855
Log of 65+ Consumption Ratio Importer	4975	-3.3208	.2004	-3.7752	-3.0171	-.7844	2.7646
Log of 65-69 Consumption Ratio Importer	4975	-5.7404	.1561	-6.0607	-5.5363	-.5412	2.2548
Log of 70+ Consumption Ratio Importer	4975	-4.0332	.2324	-4.5435	-3.6566	-.7619	2.7531
Log of 70-74 Consumption Ratio Importer	4975	-5.8787	.2155	-6.361	-5.5198	-.4005	2.5596
Log of 75-79 Consumption Ratio Importer	4975	-6.069	.2398	-6.6083	-5.6929	-.657	2.6807
Log of 80+ Consumption Ratio Importer	4975	-7.3942	.2988	-8.0052	-6.7692	-.3898	2.7008
Log of 65+ Dependency Ratio Importer	4975	-1.3242	.1769	-1.7366	-1.0876	-.9452	2.9348
Log of 65-69 Dependency Ratio Importer	4975	-2.5751	.1534	-2.9066	-2.334	-.5308	2.3568
Log of 70+ Dependency Ratio Importer	4975	-1.9529	.5521	-3.3635	-1.4361	-1.2795	3.3221
Log of 70-74 Dependency Ratio Importer	4975	-2.702	.1943	-3.0916	-2.3327	-.3771	2.5373
Log of 75-79 Dependency Ratio Importer	4975	-2.9145	.1961	-3.4046	-2.6322	-.9433	3.3257
Log of 80+ Dependency Ratio Importer	4975	-2.6948	.2414	-3.2724	-2.3379	-.6993	2.6838
Log of GDP Exporter	4600	12.7614	2.3054	7.3995	18.9072	.1146	2.5357
Log of GDP Importer	4975	14.7126	1.5157	12.2631	17.4288	.1398	2.0957
Log of Distance	4876	8.4265	.9111	2.9511	9.8826	-1.2599	4.8846
Contiguity Dummy	4825	.0191	.1368	0	1	7.0331	50.4651
Common Language Dummy	4876	.0562	.2303	0	1	3.8542	15.8552
Colonial or Dependency Relations	4951	.0307	.1725	0	1	5.441	30.604
Sibling Relationship Dummy	4951	.0477	.2131	0	1	4.246	19.0289
Both WTO Member Dummy	4975	.7487	.4338	0	1	-1.147	2.3156
Both EU Member Dummy	4975	.1357	.3425	0	1	2.1278	5.5273
RTA Dummy	4951	.3236	.4679	0	1	.7542	1.5689

Notes: This table depicts the descriptive statistics of the second gravity dataset, of which the sample is based on the AGENTA database. This dataset covers the year 2010, with 25 importing countries and 199 exporting countries. Shown in this table are the number of observations, the mean, the standard deviation, the minimum, the maximum, the skewness, and the kurtosis for each variable.

Finally, regression assumption checks for this dataset will also be done. Firstly, I check for the presence of heteroscedastic errors through both a visual check and by using a Breusch-Pagan test for heteroskedasticity. Visually, there appears to be heteroskedasticity, and indeed, the null hypothesis of constant variance is rejected with a Chi-squared value of 831.13 (p-value = 0.0000) (Breusch & Pagan, 1979). Again, to combat this, the PPML estimator as well as robust standard errors will be used (Head & Mayer, 2014; Shepherd, 2012).

Secondly, I check for the presence of multicollinearity. There is again multicollinearity when all old-age demographic dependency ratios or all consumption ratios are entered in the same model, though in most cases to a lesser extent than in the case of the NTA gravity dataset. For example, between the *65-69 consumption ratio* and the *70-74 consumption ratio,* the correlation coefficient takes a value of $\rho = -0.60$, which is slightly lower than in the previous dataset. When evaluating the multicollinearity with all the dependency ratios, and all the consumption ratios, however, the VIF rises slightly above 10. Therefore, again, a wide variety of models will be estimated, such that it can be avoided to have all consumption ratios in the same model together without much loss of information (Hair et al., 1995).

3.2.3. AGENTA disaggregated gravity dataset used for disaggregated analyses

The final dataset which will be used to estimate the effect of ageing and changing consumption patterns on international trade is the AGENTA disaggregated gravity dataset. The same 25 importing countries that are used in the AGENTA gravity dataset will be used, and again only in the year 2010, due to data availability (Istenič et al., 2016). The difference between this dataset and the AGENTA gravity dataset is that there are thirteen dependent variables included, and only 25 exporting countries, rather than the single dependent variable and 199 exporting countries. Specifically, I calculate *bilateral trade* for thirteen SITC industries based on Eurostat data (2023a; United Nations, 2006). Eurostat data was chosen as it is very reliable and easily accessible. However, as it does not cover countries outside Europe, I opted for a reduction in the number of exporting countries, and as a result, the 25 countries in the AGENTA database are in the dataset as both importers and exporters.

The thirteen *bilateral trade* variables are thus calculated based on Eurostat (2023a) data. They are transformed into real values by deflating them with their respective industry CPI, also gathered from Eurostat (2023b). The industries that are used as dependent variables are selected for their resemblance to consumption categories in studies like those of Stöver (2012). The following categories are used:

Table 3. SITC industries used for bilateral trade dependent variables

Model nr.	SITC code	Category
1	0	Food and live animals
2	111	Non-alcoholic beverages
3	112	Alcoholic beverages
4	12	Tobacco and tobacco manufactures
5	84	Articles of apparel; clothing accessories
6	85	Footwear
7	77	Electrical machinery, apparatus and appliances, and electrical parts thereof
8	82	Furniture and parts thereof
9	54	Medicinal and pharmaceutical products
10	3	Mineral fuels
11	78	Road vehicles
12	79	Other transport equipment
13	76	Telecommunications and sound-recording and reproducing apparatus and equipment

It should be noted, however, that these categories could never wholly line up with the categories of the different consumption purposes. The reason is that consumption purposes look at goods from a demand perspective, whereas the SITC industry classification looks at goods from a supply perspective. However, a careful revision shows that these categories come close, and though not all consumption purpose categories can be included (housing, for example, cannot be internationally traded), there is at least overlap for several categories.

The data for the other gravity-model variables, as well as the consumption and dependency ratios, is the same as for the AGENTA gravity database, but now for a smaller category of exporting countries. The descriptive statistics for this disaggregated database are depicted in Table 4. Notably, the descriptives for the *GDP of the exporter* and the *GDP of the importer* are the same, as the same countries are used in both cases. Furthermore, as all exporting and importing countries are EU members and WTO members, these two dummy variables have both a minimum and a maximum value of 1, and no distribution among them.

Table 4. Descriptive statistics disaggregated AGENTA gravity dataset

Variables	Obs.	Mean	Std. Dev.	Min	Max	Skew.	Kurt.
Log of Bilateral Trade Food	596	12.4989	2.641	-.8895	17.8234	-.6118	4.011
Log of Bilateral Trade Non-Alc. Beverages	464	8.4437	3.019	-4.5271	15.168	-.5836	3.7335
Log of Bilateral Trade Alc. Beverages	540	9.6488	2.9142	-.2096	16.5086	-.3497	2.8155
Log of Bilateral Trade Tobacco	388	9.4215	3.1421	-2.9177	15.7483	-.8093	4.0012
Log of Bilateral Trade Apparel	593	10.9396	2.9868	1.4313	16.9988	-.5578	2.9865
Log of Bilateral Trade Footwear	558	9.5181	3.3207	-2.3299	16.1567	-.6589	3.2016
Log of Bilateral Trade Appliances	596	12.2448	2.6964	1.086	17.9809	-.683	3.8405
Log of Bilateral Trade Furniture	585	10.3714	2.9413	-2.5812	16.9336	-.6259	3.4727
Log of Bilateral Trade Medicine	575	11.6179	3.1024	-2.3299	18.419	-.6845	3.8209
Log of Bilateral Trade Fuels	529	10.7626	3.7199	-.6559	18.4327	-.5176	2.9341
Log of Bilateral Trade Vehicles	591	12.1529	3.1854	1.8896	18.8724	-.3871	2.739
Log of Bilateral Trade Other Trans. Equip.	505	9.6259	3.3797	-.0053	18.736	-.3878	2.9967
Log of Bilateral Trade Telecomm. Equip.	595	11.544	2.8769	.9701	16.8683	-.6835	3.4659
Log of 65+ Consumption Ratio Importer	625	-3.3208	.2005	-3.7752	-3.0171	-.7844	2.7646
Log of 65-69 Consumption Ratio Importer	625	-5.7404	.1562	-6.0607	-5.5363	-.5412	2.2548
Log of 70+ Consumption Ratio Importer	625	-4.0332	.2325	-4.5435	-3.6566	-.7619	2.7531
Log of 70-74 Consumption Ratio Importer	625	-5.8787	.2156	-6.361	-5.5198	-.4005	2.5596
Log of 75-79 Consumption Ratio Importer	625	-6.069	.24	-6.6083	-5.6929	-.657	2.6807
Log of 80+ Consumption Ratio Importer	625	-7.3942	.299	-8.0052	-6.7692	-.3898	2.7008
Log of 65+ Dependency Ratio Importer	625	-1.3242	.177	-1.7366	-1.0876	-.9452	2.9348
Log of 65-69 Dependency Ratio Importer	625	-2.5751	.1535	-2.9066	-2.334	-.5308	2.3568
Log of 70+ Dependency Ratio Importer	625	-1.9529	.5525	-3.3635	-1.4361	-1.2795	3.3221
Log of 70-74 Dependency Ratio Importer	625	-2.702	.1944	-3.0916	-2.3327	-.3771	2.5373
Log of 75-79 Dependency Ratio Importer	625	-2.9145	.1962	-3.4046	-2.6322	-.9433	3.3257
Log of 80+ Dependency Ratio Importer	625	-2.6948	.2416	-3.2724	-2.3379	-.6993	2.6838
Log of GDP Exporter	625	14.7126	1.5168	12.2631	17.4288	.1398	2.0957
Log of GDP Importer	625	14.7126	1.5168	12.2631	17.4288	.1398	2.0957
Log of Distance	625	6.9869	.7988	2.9511	8.2339	-1.4448	5.7825
Contiguity Dummy	625	.1024	.3034	0	1	2.6229	7.8797
Common Language Dummy	625	.0352	.1844	0	1	5.0444	26.4456
Colonial or Dependency Relations	625	.0192	.1373	0	1	7.0073	50.1029
Sibling Relationship Dummy	625	.0416	.1998	0	1	4.5915	22.0819
Both WTO Member Dummy	625	1	0	1	1	.	.
Both EU Member Dummy	625	1	0	1	1	.	.
RTA Dummy	625	.96	.1961	0	1	-4.6949	23.0417

Notes: This table depicts the descriptive statistics of the third gravity dataset, of which the sample is based on the AGENTA database, and of which bilateral trade is considered in disaggregated forms. This dataset covers the year 2010, with 25 importing countries and 199 exporting countries. Shown in this table are the number of observations, the mean, the standard deviation, the minimum, the maximum, the skewness, and the kurtosis for each variable.

For all models, I check whether the relevant regression assumptions hold in the same way as was done for the AGENTA gravity dataset. The presence of heteroskedastic errors is found for all models, first visually, but also through the Breusch-Pagan test for heteroskedasticity. For all models, the null hypothesis of constant variance is rejected with a Chi-squared value ranging between 41.26 and 174.92 (p = 0.000) (Breusch & Pagan, 1979). Again, to combat this, the PPML estimator as well as robust standard errors will be used (Head & Mayer, 2014; Shepherd, 2012). There is also some multicollinearity in the data. Again, this only arises when all dependency ratios and all consumption ratios are estimated in the same model. Then, their VIF rises above 10, and the correlation coefficients are larger. To minimise this effect, the models will be estimated in a myriad of ways, with different combinations of dependency and consumption ratios (Hair et al., 1995).

4. EMPIRICAL RESULTS

After having carefully explained the models, estimation techniques, and data, this section turns to the estimation results. Section 4.1 considers the results of the estimation of equations (1) and (2), with the NTA gravity dataset. Section 4.2 then explains the results of the estimation of equations (1) and (2), but then with the AGENTA gravity dataset, as a sensitivity analysis. Finally, Section 4.3 highlights the results of the estimation of equation (3) with the AGENTA disaggregated gravity dataset.

4.1. Baseline Analyses

4.1.1. Old-age demographic dependency ratios and trade

The first set of models to evaluate, concerns the incremental estimations of equation (1), to see whether I can find support for hypothesis 1. I determine the effect of population ageing, measured with old-age demographic dependency ratios on trade, based on the NTA gravity dataset. The results of these estimations are depicted in Table 5, and the full results including coefficients and significance levels for the controls are shown in Table D1 of Appendix D. The model is estimated incrementally to see which variables relate to each other, and to preserve the number of observations. Model 1 depicts the most basic version of the gravity model, without any fixed effects. The variables are all significant at the 1% level, as is the model, and the model has an adjusted R-squared of 0.696. Therefore, almost 70% of the variation in *bilateral trade* is explained by the model.

Model 2 adds the variable for the *65+ dependency ratio of the importer*. The coefficients and significance levels of the other variables do not change much, and neither does the adjusted R-squared. The model is still significant at the 1% level.

Model 3 adds variables for whether the trading partners are contiguous and whether they share a common (official) language. Both these variables are positive and significant, as hypothesised. Compared to Model 2, the *65+ dependency ratio of the importer* is now insignificant. The adjusted R-squared slightly increases with this, the model is still significant at the 1% level.

Model 4 adds variables for colonial and sibling relationships. As expected, both are positive and significant. The other variables change slightly in size, though their sign and significance remain the same. The adjusted R-squared again slightly increases, and the model is still highly significant.

Model 5 adds the final variables, namely those depicting trade-facilitating agreements. Still, the *65+ dependency ratio of the importer* is insignificant. The influences of *both GATT/WTO member* and *both EU member* are insignificant, and the *both EU* member variable is negative, contrary to what was hypothesised. The *RTA* variable is, however, positive and significant, as was expected. The adjusted R-squared again increases slightly, and the model is still significant at the 1% level.

Model 6 is the complete model with all previous variables, and adds time-fixed effects. With the inclusion of these effects, all other previous variables become highly significant, and apart from the EU membership variable, they follow their hypothesised signs. As expected, with the declining importance of distance over time, the inclusion of time-fixed effects leads to a smaller coefficient for the *distance* variable. The dependency ratio variable, however, is still insignificant. The model is still highly significant, and the adjusted R-squared increases slightly.

Finally, model 7 adds importer- and exporter-fixed effects. As a result, all variables, apart from *both GATT/WTO member*, are significant. The *65+ dependency ratio of the importer*, however, as well as *both EU member*, are not following their hypothesised signs. Furthermore, many variables decrease greatly in size, such as the *GDP of the exporter* and the *GDP of the importer*, as parts of their effects are now subsumed into the importer and exporter fixed effects. The R-squared did increase again, and the model is still highly significant.

Overall, it can be said that many variables line up with the expectations. This is not the case, however, for the main independent variable, the *65+ dependency ratio of the importer*. I only find support for hypothesis 1 in Model 2, though this model is missing many important variables and is thus not complete. In Model 2, the *65+ dependency ratio of the* importer has a 5%-significant value of -0.1491, and thus as the 65+ dependency ratio of the importer increases by 1%, bilateral trade decreases with 0.15%, ceteris paribus.

Overall, the results display very constant effects throughout the estimations, though they are very variable for the old-age demographic dependency ratio. Therefore, to perhaps gather more information about the age structure of the importer populations, the models are estimated again, but this time with the *65-69 dependency ratio of the importer* and the *70+ dependency ratio of the importer*. This is done both to take an alternative version of the old age dependency ratio, as 70+ is also often used as a cut-off point, rather than 65+, but also to facilitate comparability to the consumption ratio models. The results are depicted in Table 6. The adjusted R-squared values and model significance levels are highly similar to the results with only the *65+*

dependency ratio of the importer. Though the other variables included in the model hardly change in their sign, size, and significance, more support is found for hypothesis 1. Namely, in all models but Model 7, the *70+ dependency ratio of the importer* returns negative and highly significant, meaning that bilateral trade indeed decreases as populations age.

As described in Section 3, estimations using the Poisson Pseudo-Maximum Likelihood (PPML) estimator will also be done, the results of which can be found in Appendix D, in Models 1 and 2 of Table D2. The size of the coefficients decreases strongly in both cases, and support for hypothesis 1 is found in the case of the *65+ dependency ratio of the importer*. A PPML model with fixed effects was also estimated, however, many of the variables are subsumed in the fixed effects, meaning that the true effect of ageing cannot be interpreted. These results are thus not shown in this thesis.

4.1.2. Consumption ratios and trade

The next set of models to evaluate, concerns the incremental estimations of equation (2), to see whether support for hypothesis 2 can be found. With these models, I determine the effect of population ageing and changing consumption expenditures, measured with consumption ratios, on trade, based on the NTA gravity dataset. The models are set up in the same incremental steps as previously, in Tables 5 and 6.

The results of the estimations with the *65+ consumption ratio of the importer* estimations are depicted in Table 7. The significance of all seven models is again of the highest level, and the adjusted R-squared is very similar to the estimations with the dependency ratios, too. The signs, sizes, and significance levels of the variables are nearly the same as with the *65+ dependency ratio of the importer* analyses in Table 5.

Again, only in Model 2 is support for hypothesis 2 found. Namely, in Model 2, the *65+ consumption ratio of the importer* takes a value of -0.1101 at the 5%-significance level. Therefore, as the consumption ratio of the importer increases by 1%, bilateral trade decreases by 0.11%, ceteris paribus. From this model, we can thus conclude that as populations age, and as their consumption patterns thus change, bilateral trade will change.

The results of the consumption ratio are again very variable. Therefore, to draw even more information from the data, the *65+ consumption ratio of the importer* is split up. The results of

Table 5. NTA gravity dataset analyses with 65+ demographic dependency ratio

VARIABLES	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Log of 65+ Dependency Ratio Importer		-0.1491**	0.0241	0.0659	0.0183	0.0228	1.4610***
		(0.0657)	(0.0669)	(0.0665)	(0.0669)	(0.0679)	(0.3123)
Log of GDP Exporter	1.2653***	1.2644***	1.2799***	1.2827***	1.2551***	1.2668***	0.4815***
	(0.0143)	(0.0143)	(0.0138)	(0.0137)	(0.0148)	(0.0150)	(0.1119)
Log of GDP Importer	1.1590***	1.1783***	1.1459***	1.1150***	1.1192***	1.0712***	0.9382***
	(0.0157)	(0.0190)	(0.0191)	(0.0178)	(0.0175)	(0.0168)	(0.0905)
Log of Distance	-1.1927***	-1.2058***	-1.0982***	-1.0850***	-0.9734***	-0.9351***	-1.0809***
	(0.0423)	(0.0434)	(0.0492)	(0.0483)	(0.0565)	(0.0560)	(0.0554)
Constant	-18.5970***	-19.0457***	-19.5236***	-19.1948***	-20.1766***	-19.3259***	-5.5362***
	(0.4623)	(0.4919)	(0.4979)	(0.4963)	(0.5375)	(0.5615)	(1.9687)
Observations	22,865	22,865	22,753	22,742	22,742	22,742	22,742
Adjusted R-squared	0.6959	0.6960	0.7039	0.7054	0.7084	0.7214	0.7860
Model Significance	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Control for Contiguity	No	No	Yes	Yes	Yes	Yes	Yes
Control for Common Language	No	No	Yes	Yes	Yes	Yes	Yes
Control for Colonial or Dependency Relationship	No	No	No	Yes	Yes	Yes	Yes
Control for Sibling Relationship	No	No	No	Yes	Yes	Yes	Yes
Control for Both GATT/WTO Member	No	No	No	No	Yes	Yes	Yes
Control for Both EU Member	No	No	No	No	Yes	Yes	Yes
Control for RTA	No	No	No	No	Yes	Yes	Yes
Time FE	No	No	No	No	No	Yes	Yes
Importer and Exporter FE	No	No	No	No	No	No	Yes

Notes: *** p<0.01, ** p<0.05, * p<0.1. Robust clustered standard errors in parentheses. Model (1) shows the most reduced version of the gravity model. Model (2) adds the 65+ dependency ratio of the importer. Model (3) adds the country-characteristics variables concerning common borders and common language. Model (4) adds colonial country-characteristics variables concerning dependency or sibling relationships. Model (5) adds trade agreement variables. Model (6) adds time fixed effects, and Model (7) has both time and importer and exporter fixed effects.

Table 6. NTA gravity dataset analyses with 65-69 and 70+ demographic dependency ratio

VARIABLES	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Log of 65-69 Dependency Ratio Importer		0.8646***	1.1445***	1.3532***	1.3811***	0.6781***	-0.0747
		(0.2130)	(0.2130)	(0.2089)	(0.2106)	(0.2337)	(0.3017)
Log of 70+ Dependency Ratio Importer		-0.6870***	-0.7126***	-0.8081***	-0.8698***	-0.4155***	1.2521***
		(0.1422)	(0.1416)	(0.1401)	(0.1423)	(0.1605)	(0.2732)
Log of GDP Exporter	1.2653***	1.2653***	1.2816***	1.2848***	1.2563***	1.2678***	0.4815***
	(0.0143)	(0.0143)	(0.0138)	(0.0137)	(0.0147)	(0.0150)	(0.1119)
Log of GDP Importer	1.1590***	1.1751***	1.1413***	1.1080***	1.1125***	1.0709***	0.9013***
	(0.0157)	(0.0192)	(0.0192)	(0.0180)	(0.0176)	(0.0168)	(0.0933)
Log of Distance	-1.1927***	-1.2057***	-1.0991***	-1.0856***	-0.9748***	-0.9348***	-1.0808***
	(0.0423)	(0.0433)	(0.0492)	(0.0482)	(0.0564)	(0.0560)	(0.0554)
Constant	-18.5970***	-17.7361***	-17.7484***	-17.0723***	-18.0272***	-18.4060***	-5.0122**
	(0.4623)	(0.6021)	(0.6013)	(0.5943)	(0.6326)	(0.6465)	(2.0296)
Observations	22,865	22,865	22,753	22,742	22,742	22,742	22,742
Adjusted R-squared	0.6959	0.6964	0.7045	0.7062	0.7092	0.7216	0.7860
Model Significance	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Control for Contiguity	No	No	Yes	Yes	Yes	Yes	Yes
Control for Common Language	No	No	Yes	Yes	Yes	Yes	Yes
Control for Colonial or Dependency Relationship	No	No	No	Yes	Yes	Yes	Yes
Control for Sibling Relationship	No	No	No	Yes	Yes	Yes	Yes
Control for Both GATT/WTO Member	No	No	No	No	Yes	Yes	Yes
Control for Both EU Member	No	No	No	No	Yes	Yes	Yes
Control for RTA	No	No	No	No	Yes	Yes	Yes
Time FE	No	No	No	No	No	Yes	Yes
Importer and Exporter FE	No	No	No	No	No	No	Yes

Notes: *** p<0.01, ** p<0.05, * p<0.1. Robust clustered standard errors in parentheses. Model (1) shows the most reduced version of the gravity model. Model (2) adds the 65-69 and 70+ dependency ratios of the importer. Model (3) adds the country-characteristics variables concerning common borders and common language. Model (4) adds colonial country-characteristics variables concerning dependency or sibling relationships. Model (5) adds trade agreement variables. Model (6) adds time fixed effects, and Model (7) has both time and importer and exporter fixed effects.

Table 7. NTA gravity dataset analyses with 65+ consumption ratio

VARIABLES	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Log of 65+ Consumption Ratio Importer		-0.1101**	0.0096	0.0196	-0.0014	-0.0597	0.2457
		(0.0553)	(0.0560)	(0.0559)	(0.0564)	(0.0581)	(0.2532)
Log of GDP Exporter	1.2653***	1.2645***	1.2798***	1.2822***	1.2547***	1.2658***	0.4808***
	(0.0143)	(0.0143)	(0.0138)	(0.0137)	(0.0148)	(0.0150)	(0.1115)
Log of GDP Importer	1.1590***	1.1784***	1.1473***	1.1204***	1.1219***	1.0844***	0.9387***
	(0.0157)	(0.0189)	(0.0189)	(0.0178)	(0.0176)	(0.0171)	(0.0931)
Log of Distance	-1.1927***	-1.2039***	-1.0996***	-1.0898***	-0.9747***	-0.9415***	-1.0804***
	(0.0423)	(0.0433)	(0.0489)	(0.0481)	(0.0565)	(0.0560)	(0.0555)
Constant	-18.5970***	-19.0374***	-19.5546***	-19.3068***	-20.2402***	-19.6487***	-7.6149***
	(0.4623)	(0.4917)	(0.4990)	(0.4974)	(0.5384)	(0.5705)	(1.9208)
Observations	22,865	22,865	22,753	22,742	22,742	22,742	22,742
Adjusted R-squared	0.6959	0.6960	0.7039	0.7054	0.7084	0.7214	0.7858
Model Significance	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Control for Contiguity	No	No	Yes	Yes	Yes	Yes	Yes
Control for Common Language	No	No	Yes	Yes	Yes	Yes	Yes
Control for Colonial or Dependency Relationship	No	No	No	Yes	Yes	Yes	Yes
Control for Sibling Relationship	No	No	No	Yes	Yes	Yes	Yes
Control for Both GATT/WTO Member	No	No	No	No	Yes	Yes	Yes
Control for Both EU Member	No	No	No	No	Yes	Yes	Yes
Control for RTA	No	No	No	No	Yes	Yes	Yes
Time FE	No	No	No	No	No	Yes	Yes
Importer and Exporter FE	No	No	No	No	No	No	Yes

Notes: *** p<0.01, ** p<0.05, * p<0.1. Robust clustered standard errors in parentheses. Model (1) shows the most reduced version of the gravity model. Model (2) adds the 65+ consumption ratio of the importer. Model (3) adds the country-characteristics variables concerning common borders and common language. Model (4) adds colonial country-characteristics variables concerning dependency or sibling relationships. Model (5) adds trade agreement variables. Model (6) adds time fixed effects, and Model (7) has both time and importer and exporter fixed effects.

Table 8. NTA gravity dataset analyses with 65-69 and 70+ consumption ratio

VARIABLES	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Log of 65-69 Consumption Ratio Importer		0.5928***	0.7743***	0.8469***	0.8353***	0.7208***	-1.4540***
		(0.1698)	(0.1694)	(0.1678)	(0.1675)	(0.1849)	(0.2608)
Log of 70+ Consumption Ratio Importer		-0.4522***	-0.4577***	-0.4932***	-0.5056***	-0.4872***	0.8718***
		(0.1164)	(0.1158)	(0.1150)	(0.1154)	(0.1272)	(0.2011)
Log of GDP Exporter	1.2653***	1.2647***	1.2805***	1.2830***	1.2552***	1.2671***	0.4809***
	(0.0143)	(0.0143)	(0.0138)	(0.0137)	(0.0147)	(0.0150)	(0.1116)
Log of GDP Importer	1.1590***	1.1651***	1.1309***	1.1020***	1.1039***	1.0700***	0.7839***
	(0.0157)	(0.0191)	(0.0192)	(0.0180)	(0.0177)	(0.0174)	(0.0970)
Log of Distance	-1.1927***	-1.2037***	-1.1007***	-1.0909***	-0.9770***	-0.9407***	-1.0806***
	(0.0423)	(0.0433)	(0.0489)	(0.0481)	(0.0564)	(0.0561)	(0.0555)
Constant	-18.5970***	-17.7924***	-17.9296***	-17.5262***	-18.4845***	-18.2981***	-8.2848***
	(0.4623)	(0.5834)	(0.5880)	(0.5835)	(0.6209)	(0.6463)	(1.9399)
Observations	22,865	22,865	22,753	22,742	22,742	22,742	22,742
Adjusted R-squared	0.6959	0.6963	0.7043	0.7059	0.7089	0.7218	0.7860
Model Significance	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Control for Contiguity	No	No	Yes	Yes	Yes	Yes	Yes
Control for Common Language	No	No	Yes	Yes	Yes	Yes	Yes
Control for Colonial or Dependency Relationship	No	No	No	Yes	Yes	Yes	Yes
Control for Sibling Relationship	No	No	No	Yes	Yes	Yes	Yes
Control for Both GATT/WTO Member	No	No	No	No	Yes	Yes	Yes
Control for Both EU Member	No	No	No	No	Yes	Yes	Yes
Control for RTA	No	No	No	No	Yes	Yes	Yes
Time FE	No	No	No	No	No	Yes	Yes
Importer and Exporter FE	No	No	No	No	No	No	Yes

Notes: *** p<0.01, ** p<0.05, * p<0.1. Robust clustered standard errors in parentheses. Model (1) shows the most reduced version of the gravity model. Model (2) adds the 65-69 and 70+ dependency ratios of the importer. Model (3) adds the country-characteristics variables concerning common borders and common language. Model (4) adds colonial country-characteristics variables concerning dependency or sibling relationships. Model (5) adds trade agreement variables. Model (6) adds time fixed effects, and Model (7) has both time and importer and exporter fixed effects.

these analyses can be found in Table 8. The model significance does not change between Tables 7 and 8, and the adjusted R-squared is also nearly constant. Again, compared to the analyses with the *65+ consumption ratio of the importer,* the signs, sizes, and significance levels of most variables are constant. There are changes in the effects found for the consumption ratios, though. Namely, again in all models but Model 7, I find support for hypothesis 2. Ageing, as well as a change in consumption, is captured to a larger extent in the *70+ consumption ratio of the importer*. This makes sense, as private consumption starts to decrease more heavily for most countries between ages 70 and 80. All coefficients of that variable, apart from those in Model 7, are negative and significant at the 1% level. Therefore, as posited in hypothesis 2, as the importer population ages, and thus changes its consumption patterns, bilateral trade decreases.

Equation (2) was also estimated using the PPML estimator, of which the results can also be found in Appendix D, in Models 3 and 4 of Table D2. The size of the coefficients is again lower than what was depicted in Tables 7 and 8, and no support is found for hypothesis 2, as all consumption ratios are insignificant.

Several additional analyses have been done with the NTA gravity dataset, by way of early sensitivity checks. The results of these analyses can be found in Appendix D, Table D3. Support for hypotheses 1 and 2 is found in all four models. Care should be taken in interpreting Models 1 and 3, however, as the independent variables exhibit high multicollinearity, following the explanation given in Section 3.2.

4.2. Sensitivity Analyses

4.2.1. Old-age demographic dependency ratios and trade

Further sensitivity analyses are done with the AGENTA gravity dataset. Namely, the previous results for the dependency and consumption ratios were somewhat variable between the different models. However, this variance could also be the consequence of a highly diverse importer country sample. As explained in Section 3.2, however, the AGENTA database considers only European countries, and thus considers countries that are much more similar in levels of ageing and development. Again, the first set of models concerns incremental estimations of equation (1), and I attempt to find support for hypothesis 1. The results are presented in Table 9, and the full results including coefficients and their significance levels for the controls are depicted in Table D4 of Appendix D.

Model 1 depicts the most basic version of the gravity model, without any fixed effects. The variables are all significant at the 1%-level, as is the model, and the model has an adjusted R-squared of 0.706. Therefore, 70% of the variation in *bilateral trade* is explained by the model.

Model 2 again adds the variable for the *65+ dependency ratio of the importer*. The coefficients and significance levels of the other variables do not change much, and neither do the adjusted R-squared or the model significance level. The old-age demographic dependency ratio is significant, however, it is positive, contrary to what was hypothesised.

Model 3 adds variables for contiguity and sharing a common (official) language. Both these variables are positive and significant, as hypothesised. The other coefficients hardly change. The adjusted R-squared slightly increases as a result, the model still being highly significant.

Model 4 adds variables for colonial relationships. As expected, both are positive and significant. The other variables change only slightly in size, though their sign and significance remain the same. The adjusted R-squared and the model significance are constant.

Model 5 adds the variables for trade-facilitating agreements. All three variables are positive, as hypothesised, and significant. The adjusted R-squared increases and the model significance is still stable.

Model 6 is the complete model but adds importer- and exporter-fixed effects. Time-fixed effects cannot be added in this case, as the observations are all from the same year. The adjusted R-squared increases greatly, though many coefficients now display a different size, but also different signs and significance levels. The same holds for the dependency ratio variable. Still, the model is significant at the 1% level.

Thus, many coefficients line up with the expectations, however, not the main independent variable, the *65+ dependency ratio of the importer*. I do not find support for hypothesis 1, as all coefficients are positive. This means that, for example, according to Model 2, as the 65+ dependency ratio of the importer increases by 1%, bilateral trade will increase by 0.51%, ceteris paribus. This is not what was hypothesised.

Therefore, I again attempt to draw more information from the dependency ratios by splitting them up, and estimating the model again with the *65-69 dependency ratio of the importer* and the *70+ dependency ratio of the importer*. These results are depicted in Table 10. Relative to Table 9, the model significance and the adjusted R-squared hardly change for any of the models. The same goes for the sign, sizes, and significance levels for many coefficients, except for those in Model 6, which introduces the fixed effects. The dependency ratios, however, become mostly insignificant. The only significance that is found for the old-age demographic dependency ratios is in Model 2, where the *65-69 dependency ratio of the importer* displays a negative effect, supporting hypothesis 1. This is counterintuitive, as one would expect it to be positive for this age category, and then negative in the 70+ category, like in Table 6.

Again, some estimations using the PPML estimator have also been done, of which the results are found in Appendix D, in Models 1 and 2 of Table D5. The size of the coefficients is lower compared to Tables 9 and 10, and again, no support is found for hypothesis 1.

4.2.2. Consumption ratios and trade

The next set of models estimates equation (2) incrementally, but now with data from the AGENTA gravity dataset, to determine whether there is support for hypothesis 2. The effect of both population ageing and changing consumption expenditures on trade is estimated, through the utilisation of consumption ratios. The results are depicted in Table 11.

As before, the models are estimated in the same incremental steps. All eight models display a high level of significance, as well as a similar adjusted R-squared as in Table 9. Of all variables, the signs, sizes, and significance levels are very similar to those depicted in Table 9. However, the coefficients for the *65+ consumption ratio of the importer* are now much more significant and negative, except for Model 6, which introduces the importer and exporter fixed effects. This means that in Models 2-5, support for hypothesis 2 is found, and that as the consumption ratio of the importer increases, bilateral trade decreases; ageing populations and their ageing consumption patterns will influence trade. For example, according to Model 5, as the 65+ consumption ratio of the importer increases by 1%, bilateral trade decreases by 0.96%, ceteris paribus.

Perhaps additional information can be drawn from the variables again by splitting up the *65+ consumption ratio of the importer*, as was done for the baseline analyses. The results of these estimations are depicted in Table 12. Between Tables 11 and 12, the model significance and adjusted R-squared are nearly constant. The signs, sizes, and significance levels of most variables do not change, either. In these analyses, too, support is found for hypothesis 2, as the *70+ consumption ratio of the importer* is negative and significant at the 1%-level in Models 2-5 again, like in Table 11, albeit at slightly lower values. For example, following Model 5, as the 70+ consumption ratio of the importer increases by 1%, bilateral trade decreases by 0.70%,

Table 9. AGENTA gravity dataset analyses with 65+ demographic dependency ratio

VARIABLES	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Log of 65+ Dependency Ratio Importer		0.5106**	0.6877***	0.7605***	0.7968***	-1.7501
		(0.2363)	(0.2399)	(0.2404)	(0.2350)	(2.6677)
Log of GDP Exporter	1.3198***	1.3187***	1.3197***	1.3246***	1.2669***	-1.0864
	(0.0164)	(0.0165)	(0.0166)	(0.0166)	(0.0173)	(0.8949)
Log of GDP Importer	1.2596***	1.2365***	1.2095***	1.2019***	1.2085***	0.9515***
	(0.0245)	(0.0274)	(0.0280)	(0.0280)	(0.0276)	(0.2259)
Log of Distance	-1.2566***	-1.2560***	-1.2125***	-1.1931***	-0.9281***	-1.6041***
	(0.0381)	(0.0379)	(0.0400)	(0.0392)	(0.0583)	(0.1129)
Constant	-20.8656***	-19.8381***	-19.6442***	-19.7016***	-22.1867***	2.5926
	(0.5835)	(0.7752)	(0.7765)	(0.7658)	(0.8308)	(11.3122)
Observations	4,127	4,127	4,079	4,079	4,079	4,079
Adjusted R-squared	0.7059	0.7062	0.7100	0.7121	0.7234	0.8147
Model Significance	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Control for Contiguity	No	No	Yes	Yes	Yes	Yes
Control for Common Language	No	No	Yes	Yes	Yes	Yes
Control for Colonial or Dependency Relationship	No	No	No	Yes	Yes	Yes
Control for Sibling Relationship	No	No	No	Yes	Yes	Yes
Control for Both WTO Member	No	No	No	No	Yes	Yes
Control for Both EU Member	No	No	No	No	Yes	Yes
Control for RTA	No	No	No	No	Yes	Yes
Importer and Exporter FE	No	No	No	No	No	Yes

Notes: *** p<0.01, ** p<0.05, * p<0.1. Robust clustered standard errors in parentheses. Model (1) shows the most reduced version of the gravity model. Model (2) adds the 65+ dependency ratio of the importer. Model (3) adds the country-characteristics variables concerning common borders and common language. Model (4) adds colonial country-characteristics variables concerning dependency or sibling relationships. Model (5) adds trade agreement variables. Model (6) adds importer and exporter fixed effects.

Table 10. AGENTA gravity dataset analyses with 65-69 and 70+ demographic dependency ratio

VARIABLES	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Log of 65-69 Dependency Ratio Importer		-0.4337*	-0.2271	-0.1884	-0.1488	-2.3889
		(0.2505)	(0.2560)	(0.2563)	(0.2503)	(2.6394)
Log of 70+ Dependency Ratio Importer		0.1094	0.0958	0.0904	0.0783	-4.0960
		(0.0669)	(0.0674)	(0.0673)	(0.0665)	(2.6990)
Log of GDP Exporter	1.3198***	1.3202***	1.3203***	1.3246***	1.2672***	-1.0864
	(0.0164)	(0.0164)	(0.0166)	(0.0166)	(0.0173)	(0.8949)
Log of GDP Importer	1.2596***	1.2837***	1.2606***	1.2516***	1.2573***	2.8915**
	(0.0245)	(0.0282)	(0.0288)	(0.0292)	(0.0287)	(1.4626)
Log of Distance	-1.2566***	-1.2596***	-1.2129***	-1.1966***	-0.9357***	-1.6041***
	(0.0381)	(0.0382)	(0.0404)	(0.0395)	(0.0587)	(0.1129)
Constant	-20.8656***	-22.1050***	-21.7080***	-21.7146***	-24.1262***	-37.2666
	(0.5835)	(0.9502)	(0.9610)	(0.9527)	(0.9994)	(34.1575)
Observations	4,127	4,127	4,079	4,079	4,079	4,079
Adjusted R-squared	0.7059	0.7061	0.7094	0.7115	0.7226	0.8147
Model Significance	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Control for Contiguity	No	No	Yes	Yes	Yes	Yes
Control for Common Language	No	No	Yes	Yes	Yes	Yes
Control for Colonial or Dependency Relationship	No	No	No	Yes	Yes	Yes
Control for Sibling Relationship	No	No	No	Yes	Yes	Yes
Control for Both WTO Member	No	No	No	No	Yes	Yes
Control for Both EU Member	No	No	No	No	Yes	Yes
Control for RTA	No	No	No	No	Yes	Yes
Importer and Exporter FE	No	No	No	No	No	Yes

Notes: *** p<0.01, ** p<0.05, * p<0.1. Robust clustered standard errors in parentheses. Model (1) shows the most reduced version of the gravity model. Model (2) adds the 65-69 and 70+ dependency ratios of the importer. Model (3) adds the country-characteristics variables concerning common borders and common language. Model (4) adds colonial country-characteristics variables concerning dependency or sibling relationships. Model (5) adds trade agreement variables. Model (6) adds importer and exporter fixed effects.

Table 11. AGENTA gravity dataset analyses with 65+ consumption ratio

VARIABLES	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Log of 65+ Consumption Ratio Importer		-0.9791***	-1.0913***	-0.9884***	-0.9565***	-0.1989
		(0.1921)	(0.1939)	(0.1937)	(0.1900)	(0.3032)
Log of GDP Exporter	1.3198***	1.3191***	1.3205***	1.3244***	1.2672***	-1.0864
	(0.0164)	(0.0165)	(0.0166)	(0.0166)	(0.0173)	(0.8949)
Log of GDP Importer	1.2596***	1.2948***	1.2795***	1.2697***	1.2767***	0.8117***
	(0.0245)	(0.0254)	(0.0256)	(0.0261)	(0.0257)	(0.0798)
Log of Distance	-1.2566***	-1.2568***	-1.2123***	-1.1972***	-0.9354***	-1.6041***
	(0.0381)	(0.0381)	(0.0403)	(0.0396)	(0.0584)	(0.1129)
Constant	-20.8656***	-24.6231***	-25.2236***	-24.9482***	-27.3538***	6.1818
	(0.5835)	(0.9292)	(0.9375)	(0.9419)	(0.9966)	(9.3124)
Observations	4,127	4,127	4,079	4,079	4,079	4,079
Adjusted R-squared	0.7059	0.7076	0.7115	0.7132	0.7243	0.8147
Model Significance	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Control for Contiguity	No	No	Yes	Yes	Yes	Yes
Control for Common Language	No	No	Yes	Yes	Yes	Yes
Control for Colonial or Dependency Relationship	No	No	No	Yes	Yes	Yes
Control for Sibling Relationship	No	No	No	Yes	Yes	Yes
Control for Both WTO Member	No	No	No	No	Yes	Yes
Control for Both EU Member	No	No	No	No	Yes	Yes
Control for RTA	No	No	No	No	Yes	Yes
Importer and Exporter FE	No	No	No	No	No	Yes

Notes: *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Robust clustered standard errors in parentheses. Model (1) shows the most reduced version of the gravity model. Model (2) adds the 65+ consumption ratio of the importer. Model (3) adds the country-characteristics variables concerning common borders and common language. Model (4) adds colonial country-characteristics variables concerning dependency or sibling relationships. Model (5) adds trade agreement variables. Model (6) adds importer and exporter fixed effects.

Table 12. AGENTA gravity dataset analyses with 65-69 and 70+ consumption ratio

VARIABLES	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Log of 65-69 Consumption Ratio Importer		-0.3117	-0.2537	-0.2236	-0.2363	-1.9241**
		(0.3709)	(0.3730)	(0.3744)	(0.3682)	(0.8672)
Log of 70+ Consumption Ratio Importer		-0.6731***	-0.8060***	-0.7331***	-0.6978***	0.6700
		(0.2604)	(0.2639)	(0.2631)	(0.2580)	(0.4848)
Log of GDP Exporter	1.3198***	1.3191***	1.3205***	1.3244***	1.2672***	-1.0864
	(0.0164)	(0.0165)	(0.0166)	(0.0166)	(0.0173)	(0.8949)
Log of GDP Importer	1.2596***	1.2951***	1.2800***	1.2701***	1.2771***	0.9340***
	(0.0245)	(0.0254)	(0.0256)	(0.0261)	(0.0257)	(0.0784)
Log of Distance	-1.2566***	-1.2569***	-1.2122***	-1.1972***	-0.9353***	-1.6041***
	(0.0381)	(0.0381)	(0.0403)	(0.0396)	(0.0584)	(0.1129)
Constant	-20.8656***	-25.8800***	-26.3161***	-25.9121***	-28.3549***	-3.3017
	(0.5835)	(1.6389)	(1.6508)	(1.6734)	(1.6936)	(9.9423)
Observations	4,127	4,127	4,079	4,079	4,079	4,079
Adjusted R-squared	0.7059	0.7075	0.7115	0.7131	0.7242	0.8147
Model Significance	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Control for Contiguity	No	No	Yes	Yes	Yes	Yes
Control for Common Language	No	No	Yes	Yes	Yes	Yes
Control for Colonial or Dependency Relationship	No	No	No	Yes	Yes	Yes
Control for Sibling Relationship	No	No	No	Yes	Yes	Yes
Control for Both WTO Member	No	No	No	No	Yes	Yes
Control for Both EU Member	No	No	No	No	Yes	Yes
Control for RTA	No	No	No	No	Yes	Yes
Importer and Exporter FE	No	No	No	No	No	Yes

Notes: *** p<0.01, ** p<0.05, * p<0.1. Robust clustered standard errors in parentheses. Model (1) shows the most reduced version of the gravity model. Model (2) adds the 65-69 and 70+ dependency ratios of the importer. Model (3) adds the country-characteristics variables concerning common borders and common language. Model (4) adds colonial country-characteristics variables concerning dependency or sibling relationships. Model (5) adds trade agreement variables. Model (6) adds importer and exporter fixed effects.

ceteris paribus. The variable is insignificant in Model 6, as is the *65-69 consumption ratio of the importer* in all models but Model 6, where it displays a very strong negative value. However, there is still support for hypothesis 2, and thus as the importer population ages, and as its consumption patterns change as a result, bilateral trade decreases.

Like with the baseline analyses, some estimations using the PPML estimator have also been done, of which the results are found in Appendix D, in Models 3 and 4 of Table D5. The size of the coefficients is lower compared to Tables 11 and 12, and again, no support is found for hypothesis 1.

Similar to the NTA gravity dataset, several additional analyses have been done with the AGENTA gravity dataset, to provide some further final sensitivity checks on these estimations. The results of these estimations are depicted in Appendix D, Table D6. Support for hypothesis 2 is found with the consumption ratios, and only partially found with the dependency ratios. Nevertheless, again, care should be taken in interpreting Models 1 and 3, however, as the independent variables exhibit slight multicollinearity, following the explanation given in Section 3.2.

4.3. Consumption Ratios and Disaggregated Trade

The final estimations of this thesis go even deeper into how population ageing influences trade, as the goal now is to determine *how* trade changes. In this sub-section, I attempt to discover whether, as a result of population ageing and changing consumption behaviour, trade decreases in goods of which the elderly are expected to consume relatively little, and trade increases in goods of which the elderly are expected to consume relatively much. If that is the case, then I find support for hypothesis 3.

For these estimations, I use the disaggregated AGENTA gravity dataset. The best-practice model from the previous estimations shall be used for these estimations. This model is Model 5 from Tables 11 and 12, i.e., the model that includes all relevant control variables, but that does not control for the exporter and importer fixed effects. This model gave the most reliable and constant results and is therefore estimated twenty-six times. The first thirteen instances use the *65+ consumption ratio of the importer* as the independent variable, where the dependent variable is a different SITC industry every time, and the last thirteen instances use the *65-69 consumption ratio of the importer* and the *70+ consumption ratio of the importer* as independent variables, and here, too, every model has a different SITC industry as its dependent variable. The results of these estimations can be found in Tables 13 and 14, respectively.

The first thing to note when looking at Table 13 is that the adjusted R-squared has very high variability in these models and that the model significance is very high for all of them. The gravity variables take on the correct signs when they are significant, though their sizes differ greatly. When considering the *65+ consumption ratio of the importer*, the coefficient is significant in Models 4, 7, 9, 11, and 13, and all are positive, though with different sizes. Therefore, as populations age, their trade in tobacco, appliances, medicine, vehicles, and telecommunications equipment increases.

When comparing these results to findings from Stöver (2012), they are unexpected. Namely, following her results in changing consumption patterns, it was to be expected that trade in tobacco and vehicles decrease. These are things which people in older age groups generally consume less, and thus one could expect that to affect import demand. This is not the case, however. The only industry category that does line up with expectations is trade in medicine. Very little support for hypothesis 3 is thus found.

As these results are not lining up with the expectations, it may prove insightful to again split up the consumption ratio. Therefore, in the next set of analyses, of which the results are displayed in Table 14, the *65-69 consumption ratio of the importer* and the *70+ consumption ratio of the importer* are the independent variables. For Table 14, too, the adjusted R-squared exhibits a very high variability, but the model is very significant. Significant coefficients for the consumption ratio variables are found in Models 2, 4, 7, 8, 11, and 13.

Following the expectations of Stöver (2012), I again find support for hypothesis 3 in Model 2, for trade in non-alcoholic beverages. Namely, the *70+ consumption ratio of the importer* is very negative and significant at the 5% level. As populations age, they trade less in non-alcoholic beverages. I also find partial support in Model 4, Model 8, and Model 11, for trade in tobacco, furniture, and vehicles respectively, as the *65-69 consumption ratio of the importer* is strongly negative in those instances, however, the *70+ consumption ratio of the importer* then turns positive. No support is found in Models 7 and 13, as following Stöver, trade in appliances and telecommunications equipment is expected to decrease as populations age, since the elderly are expected to consume less of these products.

Some alternative estimations were done with the disaggregated AGENTA gravity datasets, of which the results are depicted in Appendix D, in Tables D7 and D8. The results in Table D7 should be interpreted with caution, as these data present some multicollinearity. In both tables, the adjusted R-squared values fluctuate quite a bit, as was the case in Tables 13 and 14, but the models all present high significance levels. Here, too, the gravity variables mostly line up with the hypothesised effects. In these models, further support for hypothesis 3 is found, but again not for all SITC industry categories.

Table 13. Disaggregated AGENTA gravity dataset analyses with 65+ consumption ratio

VARIABLES	Model 1 Food	Model 2 Non-Alc. Beverages	Model 3 Alc. Beverages	Model 4 Tobacco	Model 5 Apparel	Model 6 Footwear	Model 7 Appliances	Model 8 Furniture	Model 9 Medicine	Model 10 Fuels	Model 11 Vehicles	Model 12 Other Trans. Equip.	Model 13 Telecomm. Equip.
Log of 65+ Consumption Ratio Importer	0.0939	-1.0830	0.1335	1.5546*	-0.2058	0.0353	0.9416***	0.6371	0.8729**	-0.7912	1.4456***	0.0990	3.0575***
	(0.2691)	(0.6727)	(0.4531)	(0.8541)	(0.3001)	(0.4761)	(0.2917)	(0.5241)	(0.4417)	(0.6428)	(0.4478)	(0.6098)	(0.4189)
Log of GDP Exporter	0.8773***	0.4561***	0.6377***	0.6463***	1.0290***	0.8531***	0.9460***	1.0348***	0.8197***	0.8427***	1.0049***	1.0518***	0.8662***
	(0.0405)	(0.0686)	(0.0576)	(0.1124)	(0.0437)	(0.0625)	(0.0401)	(0.0563)	(0.0538)	(0.0786)	(0.0470)	(0.0704)	(0.0493)
Log of GDP Importer	1.0438***	0.9264***	1.3368***	0.6641***	1.2149***	1.3759***	1.0214***	0.8183***	1.2283***	0.9952***	1.2234***	1.3171***	0.8161***
	(0.0421)	(0.0790)	(0.0576)	(0.1135)	(0.0442)	(0.0614)	(0.0458)	(0.0591)	(0.0553)	(0.0772)	(0.0471)	(0.0751)	(0.0509)
Log of Distance	-0.9218***	-1.0232***	-0.2003	-0.5985**	-1.3106***	-1.5853***	-1.4543***	-1.6221***	-0.8132***	-2.0075***	-1.7356***	-1.3144***	-1.4570***
	(0.1381)	(0.2021)	(0.1957)	(0.2908)	(0.1675)	(0.1937)	(0.1425)	(0.1845)	(0.1762)	(0.2473)	(0.1779)	(0.2452)	(0.1802)
Constant	-9.1756***	-9.0430**	-18.1438***	-1.1848	-13.6783***	-12.4176***	-3.3792**	-3.4762	-10.1489***	-5.3368	-3.7005	-16.3876***	7.1534***
	(1.8602)	(3.5076)	(2.6559)	(3.6871)	(1.6471)	(2.5262)	(1.7169)	(2.6862)	(2.4546)	(3.3317)	(2.4053)	(2.9297)	(2.2340)
Observations	596	464	540	388	593	558	596	585	575	529	591	505	595
Adjusted R-squared	0.7287	0.4153	0.5566	0.2087	0.7239	0.6084	0.7455	0.5951	0.5466	0.4854	0.7055	0.5456	0.5979
Model Significance	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Control for Contiguity	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control for Common Language	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control for Colonial or Dependency Relationship	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control for Sibling Relationship	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control for Both WTO Member	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control for Both EU Member	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control for RTA	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: *** p<0.01, ** p<0.05, * p<0.1. Robust clustered standard errors in parentheses. The estimation in this table is the most complete specification, with the 65+ consumption ratio of the importer. It is a regression model without fixed effects. Model (1) estimates the model for the *Food and live animals* industry. Model (2) estimates the model for the *Non-alcoholic beverages* industry. Model (3) estimates the model for the *Alcoholic beverages* industry. Model (4) estimates the model for the *Tobacco and tobacco manufactures* industry. Model (5) estimates the model for the *Articles of apparel; clothing accessories* industry. Model (6) estimates the model for the *Footwear* industry. Model (7) estimates the model for the *Electrical machinery, apparatus and appliances, and electrical parts thereof* industry. Model (8) estimates the model for the *Furniture and parts thereof* industry. Model (9) estimates the model for the *Medicinal and pharmaceutical products* industry. Model (10) estimates the model for the *Mineral fuels* industry. Model (11) estimates the model for the *Road vehicles* industry. Model (12) estimates the model for the *Other transport equipment* industry. Model (13) estimates the model for the *Telecommunications and sound-recording and reproducing apparatus and equipment* industry.

Table 14. Disaggregated AGENTA gravity dataset analyses with 65-69 and 70+ consumption ratio

VARIABLES	Model 1 Food	Model 2 Non-Alc. Beverages	Model 3 Alc. Beverages	Model 4 Tobacco	Model 5 Apparel	Model 6 Footwear	Model 7 Appliances	Model 8 Furniture	Model 9 Medicine	Model 10 Fuels	Model 11 Vehicles	Model 12 Other Trans. Equip.	Model 13 Telecomm. Equip.
Log of 65-69 Consumption Ratio Importer	-0.3161	2.0513**	-0.7366	-6.5247***	0.4907	-0.9842	1.4866***	-1.1318*	-0.2660	0.4054	-1.1732*	-0.7319	3.1907***
	(0.5471)	(1.0199)	(0.8207)	(1.4123)	(0.6384)	(0.8083)	(0.5103)	(0.6677)	(0.8391)	(1.1435)	(0.6761)	(0.9972)	(0.8112)
Log of 70+ Consumption Ratio Importer	0.2719	-2.1793**	0.5670	5.4174***	-0.4731	0.6141	-0.0422	1.2122**	0.9261	-0.9175	1.9534***	0.5346	0.8248
	(0.3736)	(0.8558)	(0.6016)	(1.0709)	(0.4392)	(0.5901)	(0.3750)	(0.5821)	(0.6167)	(0.8035)	(0.5135)	(0.7442)	(0.5349)
Log of GDP Exporter	0.8775***	0.4561***	0.6374***	0.6785***	1.0290***	0.8526***	0.9457***	1.0356***	0.8196***	0.8430***	1.0048***	1.0532***	0.8644***
	(0.0406)	(0.0680)	(0.0575)	(0.1086)	(0.0438)	(0.0624)	(0.0399)	(0.0562)	(0.0538)	(0.0786)	(0.0471)	(0.0701)	(0.0487)
Log of GDP Importer	1.0426***	0.9352***	1.3328***	0.6378***	1.2171***	1.3721***	1.0244***	0.8157***	1.2259***	0.9959***	1.2179***	1.3152***	0.8201***
	(0.0425)	(0.0772)	(0.0579)	(0.1093)	(0.0439)	(0.0616)	(0.0453)	(0.0599)	(0.0558)	(0.0773)	(0.0473)	(0.0752)	(0.0504)
Log of Distance	-0.9179***	-1.0343***	-0.1944	-0.5644**	-1.3165***	-1.5774***	-1.4664***	-1.6128***	-0.8082***	-2.0088***	-1.7196***	-1.3116***	-1.4777***
	(0.1369)	(0.2053)	(0.1949)	(0.2755)	(0.1676)	(0.1943)	(0.1434)	(0.1821)	(0.1745)	(0.2479)	(0.1745)	(0.2445)	(0.1807)
Constant	-10.2212***	-2.4987	-20.5072***	-22.3984***	-12.0736***	-15.7003***	1.9064	-7.2455**	-10.8379***	-4.0880	-7.3928**	-18.7772***	18.7642***
	(2.5368)	(4.8011)	(3.9912)	(6.2726)	(2.7624)	(4.1021)	(2.3579)	(3.6355)	(3.6916)	(5.4083)	(3.5357)	(4.6599)	(3.6735)
Observations	596	464	540	388	593	558	596	585	575	529	591	505	595
Adjusted R-squared	0.7284	0.4206	0.5565	0.2585	0.7238	0.6086	0.7473	0.5965	0.5462	0.4847	0.7077	0.5452	0.6045
Model Significance	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Control for Contiguity	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control for Common Language	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control for Colonial or Dependency Relationship	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control for Sibling Relationship	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control for Both WTO Member	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control for Both EU Member	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control for RTA	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: *** p<0.01, ** p<0.05, * p<0.1. Robust clustered standard errors in parentheses. The estimation in this table is the most complete specification, with the 65-69 and 70+ consumption ratio of the importer. It is a regression model without fixed effects. Model (1) estimates the model for the *Food and live animals* industry. Model (2) estimates the model for the *Non-alcoholic beverages* industry. Model (3) estimates the model for the *Alcoholic beverages* industry. Model (4) estimates the model for the *Tobacco and tobacco manufactures* industry. Model (5) estimates the model for the *Articles of apparel; clothing accessories* industry. Model (6) estimates the model for the *Footwear* industry. Model (7) estimates the model for the *Electrical machinery, apparatus and appliances, and electrical parts thereof* industry. Model (8) estimates the model for the *Furniture and parts thereof* industry. Model (9) estimates the model for the *Medicinal and pharmaceutical products* industry. Model (10) estimates the model for the *Mineral fuels* industry. Model (11) estimates the model for the *Road vehicles* industry. Model (12) estimates the model for the *Other transport equipment* industry. Model (13) estimates the model for the *Telecommunications and sound-recording and reproducing apparatus and equipment* industry.

5. DISCUSSION AND CONCLUSION

In this section, I conclude this thesis. I first turn to an evaluation of the results and put their implications into perspective. Then I evaluate several limitations of this research, while also putting forward some recommendations for future research. I conclude by answering the research questions.

5.1. Implications

Having conducted all the analyses, in this section, I turn to the implications of the results. Overall, I have found consistent support for both my first and second hypotheses. Bilateral trade thus decreased following increasing old-age demographic dependency ratios and consumption ratios. However, support for the third hypothesis is lacking. The models did not return many significant consumption ratios, and thus the effect that I sought to establish seems to be absent. Overall, the effect of the gravity variables stayed very constant throughout all the analyses. This was not the case when introducing importer- and exporter-fixed effects, as these effects likely subsume much of the variation in these variables. In addition, there was quite a big difference between models with just the 65+ dependency and consumption ratios, and those with 65-69 and 70+ ratios. This is because the distribution in both ageing and consumption changes heavily even after age 65. Splitting up these ratios thus provides much more information, changing the coefficients between the different models. Furthermore, the PPML estimations that were depicted in Appendix D show changes in all coefficients relative to the earlier estimations. PPML with robust clustered standard errors tends to be considerably downward biased (Pfaffermayr, 2023). Still, it is useful to consider the results, as the estimator aids in addressing some of the econometric issues discussed in Section 3.

This link that has been found between ageing and trade can be considered a multiplier effect. Namely, there is the effect of increases in the actual size of the elderly which is detrimental. For example, the old-age demographic dependency ratios may influence trade for example through the shrinking of the labour supply of a country, which reduces income and thus import demand (Jafrin et al., 2021; Tian et al., 2011). However, there is also the added effect of changing consumption structures. Specifically, as people age, their private consumption decreases, following life-cycle theory and the retirement-consumption puzzle (Lefèbvre, 2006; Modigliani & Brumberg, 1954, 1990; World Trade Organization, 2013). This decrease in private consumption as a person ages, combined with the increased share of the elderly in the population, is thus found to be detrimental to international trade.

The reason that these found effects are so important, is that they demonstrate that population ageing can affect the economy in yet another way than once thought. Specifically, as populations age and their consumption patterns change, trade changes according to this, and this may induce sectoral shifts (Lefèbvre, 2006). Therefore, beyond pressuring the pension system and inequality and the like, population ageing influences not only international trade relations, but the sectoral make-up of the economy. This effect is further pressured by population shrinking. The decline in the absolute size of populations, another phenomenon of recent decades, namely leads to a reduced ability to provide goods and services both regionally and nationally, and we thus turn to trade to save this problem. This makes the effect that ageing has on the economy through changes in consumption and trade even more detrimental, and that also makes this strand of literature so important.

This discussion indicates that there is high policy relevance for these effects. The detrimental effect of population ageing on trade needs to be limited, through the use of policies that stimulate consumption in older ages, too, or that facilitate higher levels of trade even as consumption in some industries falters. As such, the detrimental effect that ageing has on trade will have limited repercussions for the domestic economy (Singh, 2010).

5.2. Limitations and Recommendations for Future Studies

Despite the extensive analyses estimated, there are several limitations to this thesis. Firstly, as mentioned already in Section 3, the income data that both the NTA and the AGENTA supply are very accurate, as they are based on income tax reports (Lee & Mason, 2011a; Lee & Mason, 2011b). However, the same cannot be said for their consumption data. Namely, the consumption data is often based on household surveys, and are thus far less accurate. Secondly, the data that the NTA and the AGENTA supply may not be entirely comparable. Namely, the NTA project uses local, country-specific research teams, which can thus take country-specific details into account. The AGENTA project does not rely on such country-specific teams, meaning that its data does not take to these country-specific details so well. However, as it uses a more widespread research team, its accounts serve better for easy comparisons between countries, in addition to distinguishing between genders (Istenič et al., 2016; Lee & Mason, 2017). Thirdly, the level of trade costs over time has declined. Trade costs are difficult to estimate, however, and to that end, distance is used, as well as other trade-facilitating characteristics, such as contiguity, common language, and EU membership. Nevertheless, these factors do not always accurately display the decrease in trade costs, as most of them are time-invariant (Yotov et al., 2016). For example, once a country has a common border with another country, this is highly unlikely to change. A limitation of gravity models to thus always be mindful of is that trade costs are not always very accurate and may thus be overestimated.

Several recommendations can also be put forward, as avenues for further research while taking the above limitations into account. A first recommendation is to enhance the analysis of the disaggregated trade models by computing consumption ratios that are based on age-specific consumption in consumption purposes related to that trade industry. However, this data is, as of yet, unavailable, but this extension might prove very insightful and much more accurate for the disaggregated analyses should the data become available. A second extension is to use economic dependency ratios instead of consumption ratios. In an earlier version of the analyses these were used, however, as they are mainly a proxy for how consumption is financed, they are not extremely relevant in this particular research. Should one be interested in the effect of sustainability of the pension system on trade, for example, these dependency ratios might be of use. Finally, an extension that might prove to be very insightful is splitting the sample in the disaggregated trade analyses. Namely, as consumption after age 65 changes in different ways for different countries, results may be very mixed. Dividing countries over three different samples, such as 'fairly flat consumption', 'small decrease in consumption', and 'large decrease in consumption' after age 65, might make the results more significant, both statistically and economically.

5.3. Conclusion

This thesis has attempted to estimate the effect of ageing populations on international trade, by continuing upon my previous work (Meijer, 2022). By adding to the analysis through the introduction of the consumption ratios, I use the NTA approach, and thus take a big step forward. Namely, this strategy allows me to distinguish the multiplier effect that population ageing has on international trade. Specifically, as populations age, there is not only a change in the size of elderly people, which influences the level of trade, but there is also the decrease in private consumption patterns in the elderly ages that amplifies this effect. To estimate this effect, the analysis was split up into three parts. Firstly, I estimated the effect of ageing on international trade through the use of various old-age demographic dependency ratios of the importer. In both my baseline and sensitivity analyses, evidence was found that as the dependency ratio increases, bilateral trade decreases. Therefore, to answer my first sub-research question *"Does the dependency ratio of the importer influence the level of bilateral trade?"*, I indeed find this influence. Secondly, I estimated the effect of ageing on international trade by using consumption ratios as proxies for both population ageing and changing consumption behaviour in older ages. Again, in both my baseline and sensitivity analyses, I find that the various combinations of consumption ratios of the importer demonstrate a negative effect; as the consumption ratio increases, bilateral trade decreases. Thus, my second sub-research question, *"Does the change in consumption over the life course influence the level of bilateral trade as populations age?"* can also be answered in the affirmative. Finally, I take the analysis one step further by disaggregating trade, to see how trade might change as populations age. These analyses are inconclusive, as the industries for which I expected to see a decline, often witness an increase in trade as populations age. Therefore, to answer my third sub-research question *"How does bilateral trade change as populations age?"*, I posit that trade decreases in some industries where the elderly are expected to consume less, and that trade increases in some industries where the elderly are expected to consume more, as hypothesised, however, the evidence is not conclusive for many sectors. This warrants further research. The research question of this thesis is:

> *"Does the age structure of the importer's population influence the level of bilateral trade?"*

Based on the sub-research questions, the hypotheses, and all the analyses, I conclude that the structure of the importer's population indeed influences the level of bilateral trade. The extensive estimations have demonstrated a somewhat robust effect. Namely, when taking solely the age structure of the importer into account, I already find negative effects of ageing on bilateral trade. By taking the step towards including age-specific consumption patterns, I strengthen my findings even more, as the change in the population age structure of the importer influences trade not only through changes in sizes of the elderly population, but also certainly by their levels of private consumption, which changes throughout the life course. Though there is certainly still room for future research, this research has established the importance of considering the effect of population ageing on international trade. Namely, as consumption patterns and thus trade change, they can bring about sectoral shifts (Lefèbvre, 2006). These shifts may have further effects on international trade relations, but most certainly on the domestic economy, further extending the effect that population ageing can have.

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APPENDICES

Appendix A. List of Included Variables

Table A 1. List of included variables

Variable name	Description	Source
Bilateral trade	Importer-reported bilateral trade values, either aggregate or at the SITC industry level. The value is reported in real values. This variable was based on CEPII's Gravity Database.	Head & Mayer, 2014
Dependency ratio of the importer	Dependency ratio of the importer, calculated as the number of persons in the relevant age group, divided by the number of people between ages 20 and 64. This variable was based on the United Nations World Population Prospects Indicators.	United Nations, 2022
Consumption ratio of the importer	Consumption ratio of the importer, calculated as the aggregate consumption of all persons in the relevant age group, relative to the aggregate consumption of the total population. This variable was based on the NTA project and AGENTA project data.	Lee & Mason, 2011b (NTA) Istenič et al., 2016 (AGENTA)
GDP of the exporter	GDP per capita of the exporter, reported in real values. This variable was based on CEPII's Gravity Database, which in turn obtained it from the World Bank Development Indicators.	Head & Mayer, 2014
GDP of the importer	GDP per capita of the importer, reported in real values. This variable was based on CEPII's Gravity Database, which in turn obtained it from the World Bank Development Indicators.	Head & Mayer, 2014
Distance	The distance between the capitals of the exporter and the importer, measured in kilometres. This variable was taken from CEPII's Gravity Database, where it was in turn taken from CEPII's GeoDist Database.	Head & Mayer, 2014

Contiguity	A dummy equal to 1 if the exporter and importer are contiguous to one another. This variable was taken from CEPII's Gravity Database, which in turn obtained it from CEPII's GeoDist Database.	Head & Mayer, 2014
Common official language	A dummy equal to 1 if the exporter and the importer share an official or primary language. This variable was taken from CEPII's Gravity Database, which in turn obtained it from CEPII's GeoDist Database.	Head & Mayer, 2014
Colonial or dependency relationship between the trading partners	A dummy equal to 1 if the exporter and the importer were ever in a colonial or dependency relationship. This variable was taken from CEPII's Gravity Database, which in turn derived it from the Colonial Ties Database.	Head & Mayer, 2014
Sibling relationship between the trading partners	A dummy equal to 1 if the exporter and the importer were ever in a sibling relationship, meaning that they ever had the same hegemon. This variable was taken from CEPII's Gravity Database, which in turn derived it from the Colonial Ties Database.	Head & Mayer, 2014
Trading partners are both (GATT/) WTO members	A dummy equal to 1 if the exporter and the importer are both members of the GATT and/or WTO in a certain year. This variable was based on the exporter and importer GATT and WTO membership dummies, obtained from CEPII's Gravity Database, which in turn obtained it from the WTO.	Head & Mayer, 2014
Trading partners are both EU members	A dummy equal to 1 if the exporter and the importer are both members of the European Union in a certain year. This variable was based on the exporter and importer EU membership dummies, obtained from CEPII's Gravity Database, which in turn obtained it from the European Union.	Head & Mayer, 2014

Share a regional trade agreement	A dummy equal to 1 if the exporter and the importer share a regional trade agreement of any type in a certain year. This variable was obtained from CEPII's Gravity Database, which in turn obtained it from the WTO.	Head & Mayer, 2014

Appendix B. List of Included Observations in NTA Gravity Dataset

Table B 1. List of included importing country observations in the NTA gravity dataset

Alpha-3 code	Country	Years included
ARG	Argentina	1997, 2010, 2016
AUS	Australia	2004, 2010
AUT	Austria	1995, 2000, 2005, 2010
BEN	Benin	2007
BWA	Botswana	2010
BRA	Brazil	1996, 2002, 2008
BFA	Burkina Faso	2014
KHM	Cambodia	2009
CMR	Cameroon	2014
CAN	Canada	2006, 2011
CAF	Central African Republic	2008
TCD	Chad	2011
CHL	Chile	1987, 1997, 2018
CHN	China	1995, 2002, 2009, 2014
COL	Colombia	2008, 2014
CRI	Costa Rica	2004, 2013
SLV	El Salvador	2010
ETH	Ethiopia	2005
FIN	Finland	2004, 2006
FRA	France	2001, 2005, 2011
GAB	Gabon	2005
GMB	Gambia	2015
DEU	Germany	2003, 2008
GHA	Ghana	2005
GIN	Guinea	2012
GNB	Guinea-Bissau	2010
HUN	Hungary	1995, 2000, 2005
IND	India	2004
IDN	Indonesia	2005
ITA	Italy	2008
JAM	Jamaica	2002
JPN	Japan	2004
KEN	Kenya	1994, 2005

LAO	Laos	2012
MDV	Maldives	2010
MLI	Mali	2015
MRT	Mauritania	2014
MEX	Mexico	2004, 2010, 2014
MDA	Moldova	2014
MNG	Mongolia	2014
MOZ	Mozambique	2008
NAM	Namibia	2012
NER	Niger	2014
NGA	Nigeria	2004, 2009, 2016
PRY	Paraguay	2012
PER	Peru	2007, 2014
PHL	Philippines	1990, 1995, 1999, 2000, 2004, 2005, 2007, 2010, 2011, 2015
POL	Poland	2012
RUS	Russia	2013, 2016
STP	Sao Tome and Principe	2012
SEN	Senegal	2005, 2011
SLE	Sierra Leone	2011
SGP	Singapore	2013
SVN	Slovenia	2004, 2010
ZAF	South Africa	2005
KOR	South Korea	2000, 2010-2019
ESP	Spain	2000
SWZ	Eswatini	2011
SWE	Sweden	2000, 2002-2006
TWN	Taiwan	1993, 1998, 2015
THA	Thailand	1996, 2004, 2011, 2017
TLS	Timor-Leste	2011
TUR	Türkiye	2006
URY	Uruguay	1994, 2006, 2013
USA	United States of America	1981-2003, 2006-2011
VNM	Vietnam	2008

Appendix C. List of Included Observations in AGENTA Gravity Dataset

Table C 1. List of included importing country observations in the AGENTA gravity dataset

Alpha-3 code	Country
AUT	Austria
BEL	Belgium
BGR	Bulgaria
CYP	Cyprus
CZE	Czech Republic
DNK	Denmark
EST	Estonia
FIN	Finland
FRA	France
DEU	Germany
GRC	Greece
HUN	Hungary
IRL	Ireland
ITA	Italy
LVA	Latvia
LTU	Lithuania
LUX	Luxembourg
POL	Poland
PRT	Portugal
ROU	Romania
SVK	Slovakia
SVN	Slovenia
ESP	Spain
SWE	Sweden
GBR	United Kingdom

Appendix D. Alternative Estimations

Table D 1. Complete NTA gravity dataset analyses with 65+ demographic dependency ratio

VARIABLES	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Log of 65+ Dependency Ratio Importer		-0.1491**	0.0241	0.0659	0.0183	0.0228	1.4610***
		(0.0657)	(0.0669)	(0.0665)	(0.0669)	(0.0679)	(0.3123)
Log of GDP Exporter	1.2653***	1.2644***	1.2799***	1.2827***	1.2551***	1.2668***	0.4815***
	(0.0143)	(0.0143)	(0.0138)	(0.0137)	(0.0148)	(0.0150)	(0.1119)
Log of GDP Importer	1.1590***	1.1783***	1.1459***	1.1150***	1.1192***	1.0712***	0.9382***
	(0.0157)	(0.0190)	(0.0191)	(0.0178)	(0.0175)	(0.0168)	(0.0905)
Log of Distance	-1.1927***	-1.2058***	-1.0982***	-1.0850***	-0.9734***	-0.9351***	-1.0809***
	(0.0423)	(0.0434)	(0.0492)	(0.0483)	(0.0565)	(0.0560)	(0.0554)
Contiguity Dummy			0.6371***	0.6300***	0.4312**	0.4906**	0.6042***
			(0.2146)	(0.2176)	(0.2082)	(0.2231)	(0.1834)
Common Language Dummy			1.0150***	0.6867***	0.6400***	0.6627***	0.5990***
			(0.0958)	(0.1329)	(0.1325)	(0.1329)	(0.1101)
Colonial or Dependency Relationship Dummy				0.6100**	0.7321***	0.5823**	0.6404***
				(0.2667)	(0.2576)	(0.2849)	(0.2074)
Sibling Relationship Dummy				0.5580***	0.5631***	0.4130***	0.5025***
				(0.1298)	(0.1277)	(0.1286)	(0.1125)
Both GATT/WTO Member Dummy					0.1235	0.3551***	-0.0211
					(0.0854)	(0.0868)	(0.1022)
Both EU Member Dummy					-0.2049	-0.4479***	-0.3656***
					(0.1254)	(0.1309)	(0.1277)
RTA Dummy					0.7740***	0.9324***	0.6516***
					(0.0756)	(0.0779)	(0.0760)
Constant	-18.5970***	-19.0457***	-19.5236***	-19.1948***	-20.1766***	-19.3259***	-5.5362***
	(0.4623)	(0.4919)	(0.4979)	(0.4963)	(0.5375)	(0.5615)	(1.9687)
Observations	22,865	22,865	22,753	22,742	22,742	22,742	22,742
Adjusted R-squared	0.6959	0.6960	0.7039	0.7054	0.7084	0.7214	0.7860
Model Significance	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Time FE	No	No	No	No	No	Yes	Yes
Importer and Exporter FE	No	No	No	No	No	No	Yes

Notes: *** p<0.01, ** p<0.05, * p<0.1. Robust clustered standard errors in parentheses. Model (1) shows the most reduced version of the gravity model. Model (2) adds the 65+ dependency ratio of the importer. Model (3) adds the country-characteristics variables concerning common borders and common language. Model (4) adds colonial country-characteristics variables concerning dependency or sibling relationships. Model (5) adds trade agreement variables. Model (6) adds time fixed effects, and Model (7) has both time and importer and exporter fixed effects.

Table D 2. NTA gravity dataset analyses with PPML estimator

VARIABLES	Model 1	Model 2	Model 3	Model 4
Log of 65+ Dependency Ratio Importer	-0.1774*			
	(0.1076)			
Log of 65-69 Dependency Ratio Importer		0.0760		
		(0.3414)		
Log of 70+ Dependency Ratio Importer		-0.2061		
		(0.2713)		
Log of 65+ Consumption Ratio Importer			-0.1106	
			(0.1177)	
Log of 65-69 Consumption Ratio Importer				0.0169
				(0.1997)
Log of 70+ Consumption Ratio Importer				-0.1068
				(0.1775)
Log of GDP Exporter	0.8614***	0.8615***	0.8615***	0.8616***
	(0.0354)	(0.0352)	(0.0357)	(0.0356)
Log of GDP Importer	0.8700***	0.8718***	0.8722***	0.8722***
	(0.0425)	(0.0404)	(0.0377)	(0.0379)
Log of Distance	-0.3519***	-0.3509***	-0.3490***	-0.3487***
	(0.0805)	(0.0798)	(0.0800)	(0.0797)
Constant	-14.4092***	-14.3667***	-14.3980***	-14.3819***
	(1.4877)	(1.6768)	(1.3339)	(1.4339)
Observations	22,742	22,742	22,742	22,742
R-squared	0.7636	0.7627	0.7627	0.7625
Model Significance	0.0000	0.0000	0.0000	0.0000
Control for Contiguity	Yes	Yes	Yes	Yes
Control for Common Language	Yes	Yes	Yes	Yes
Control for Colonial or Dependency Relationship	Yes	Yes	Yes	Yes
Control for Sibling Relationship	Yes	Yes	Yes	Yes
Control for Both GATT/WTO Member	Yes	Yes	Yes	Yes
Control for Both EU Member	Yes	Yes	Yes	Yes
Control for RTA	Yes	Yes	Yes	Yes

Notes: *** p<0.01, ** p<0.05, * p<0.1. Robust clustered standard errors in parentheses. This table contains the results of the PPML estimations of earlier models with the NTA gravity dataset. Model (1) is a PPML estimation which includes the 65+ dependency ratio. Model (2) is a PPML estimation which includes the 65-69 and 70+ dependency ratios. Model (3) is a PPML estimation which includes the 65+ consumption ratio. Model (4) is a PPML estimation which includes the 65-69 and 70+ consumption ratios.

Table D 3. NTA gravity dataset analyses with alternative IV combinations

VARIABLES	Model 1	Model 2	Model 3	Model 4
Log of 65-69 Dependency Ratio Importer	-0.4527**	1.5790***		
	(0.2079)	(0.1678)		
Log of 70-74 Dependency Ratio Importer	1.9523***			
	(0.2136)			
Log of 75-79 Dependency Ratio Importer	0.6903***			
	(0.2276)			
Log of 80+ Dependency Ratio Importer	-1.4540***	-0.7934***		
	(0.1291)	(0.0808)		
Log of 65-69 Consumption Ratio Importer			-1.0730***	0.9483***
			(0.1710)	(0.1308)
Log of 70-74 Consumption Ratio Importer			1.9636***	
			(0.2101)	
Log of 75-79 Consumption Ratio Importer			0.5767***	
			(0.2139)	
Log of 80+ Consumption Ratio Importer			-1.0085***	-0.4487***
			(0.1077)	(0.0646)
Log of GDP Exporter	1.2609***	1.2573***	1.2602***	1.2559***
	(0.0147)	(0.0147)	(0.0147)	(0.0147)
Log of GDP Importer	1.1239***	1.1199***	1.1028***	1.1013***
	(0.0177)	(0.0177)	(0.0178)	(0.0178)
Log of Distance	-0.9318***	-0.9626***	-0.9491***	-0.9723***
	(0.0570)	(0.0564)	(0.0570)	(0.0564)
Constant	-18.5109***	-18.4802***	-18.3821***	-18.4974***
	(0.5930)	(0.5932)	(0.5918)	(0.5916)
Observations	22,742	22,742	22,742	22,742
Adjusted R-squared	0.7130	0.7107	0.7123	0.7097
Model Significance	0.0000	0.0000	0.0000	0.0000
Control for Contiguity	Yes	Yes	Yes	Yes
Control for Common Language	Yes	Yes	Yes	Yes
Control for Colonial or Dependency Relationship	Yes	Yes	Yes	Yes
Control for Sibling Relationship	Yes	Yes	Yes	Yes
Control for Both GATT/WTO Member	Yes	Yes	Yes	Yes
Control for Both EU Member	Yes	Yes	Yes	Yes
Control for RTA	Yes	Yes	Yes	Yes

Notes: *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Robust clustered standard errors in parentheses. Model (1) is an OLS regression model which includes dependency ratios of all four age groups. Model (2) is an OLS regression which includes dependency ratios for the 65-69 and 80+ age groups to reduce multicollinearity concerns. Model (3) is an OLS regression model which includes consumption ratios for all four age groups. Model (4) is an OLS regression model which includes consumption ratios for the 65-69 and 80+ age groups to reduce multicollinearity concerns.

Table D 4. Complete AGENTA gravity dataset analyses with 65+ demographic dependency ratio

VARIABLES	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Log of 65+ Dependency Ratio Importer		0.5106**	0.6877***	0.7605***	0.7968***	-1.7501
		(0.2363)	(0.2399)	(0.2404)	(0.2350)	(2.6677)
Log of GDP Exporter	1.3198***	1.3187***	1.3197***	1.3246***	1.2669***	-1.0864
	(0.0164)	(0.0165)	(0.0166)	(0.0166)	(0.0173)	(0.8949)
Log of GDP Importer	1.2596***	1.2365***	1.2095***	1.2019***	1.2085***	0.9515***
	(0.0245)	(0.0274)	(0.0280)	(0.0280)	(0.0276)	(0.2259)
Log of Distance	-1.2566***	-1.2560***	-1.2125***	-1.1931***	-0.9281***	-1.6041***
	(0.0381)	(0.0379)	(0.0400)	(0.0392)	(0.0583)	(0.1129)
Contiguity Dummy			0.6971***	0.6725***	0.7004***	-0.2648
			(0.2572)	(0.2430)	(0.2532)	(0.2265)
Common Language Dummy			0.9172***	0.4259**	0.3583**	0.4458***
			(0.1569)	(0.1808)	(0.1767)	(0.1626)
Colonial or Dependency Relationship Dummy				1.1950***	1.2592***	1.1806***
				(0.1961)	(0.1920)	(0.1905)
Sibling Relationship Dummy				0.5721***	0.8383***	0.7598***
				(0.2052)	(0.1992)	(0.1804)
Both WTO Member Dummy					0.8773***	10.6864***
					(0.1356)	(1.7728)
Both EU Member Dummy					0.9462***	4.4227
					(0.1042)	(3.3072)
RTA Dummy					0.1758*	3.6089***
					(0.1040)	(0.5378)
Constant	-20.8656***	-19.8381***	-19.6442***	-19.7016***	-22.1867***	2.5926
	(0.5835)	(0.7752)	(0.7765)	(0.7658)	(0.8308)	(11.3122)
Observations	4,127	4,127	4,079	4,079	4,079	4,079
Adjusted R-squared	0.7059	0.7062	0.7100	0.7121	0.7234	0.8147
Model Significance	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Importer and Exporter FE	No	No	No	No	No	Yes

Notes: *** p<0.01, ** p<0.05, * p<0.1. Robust clustered standard errors in parentheses. Model (1) shows the most reduced version of the gravity model. Model (2) adds the 65+ dependency ratio of the importer. Model (3) adds the country-characteristics variables concerning common borders and common language. Model (4) adds colonial country-characteristics variables concerning dependency or sibling relationships. Model (5) adds trade agreement variables. Model (6) adds importer and exporter fixed effects.

Table D 5. AGENTA gravity dataset analyses with PPML estimator

VARIABLES	Model 1	Model 2	Model 3	Model 4
Log of 65+ Dependency Ratio Importer	0.5723**			
	(0.2776)			
Log of 65-69 Dependency Ratio Importer		0.5383**		
		(0.2465)		
Log of 70+ Dependency Ratio Importer		-0.0002		
		(0.0739)		
Log of 65+ Consumption Ratio Importer			0.4191*	
			(0.2244)	
Log of 65-69 Consumption Ratio Importer				0.4775
				(0.3837)
Log of 70+ Consumption Ratio Importer				0.0605
				(0.2595)
Log of GDP Exporter	0.8195***	0.8195***	0.8170***	0.8174***
	(0.0221)	(0.0221)	(0.0224)	(0.0224)
Log of GDP Importer	0.7737***	0.7934***	0.7927***	0.7925***
	(0.0321)	(0.0358)	(0.0300)	(0.0299)
Log of Distance	-0.4399***	-0.4356***	-0.4306***	-0.4323***
	(0.0926)	(0.0919)	(0.0935)	(0.0929)
Constant	-10.6676***	-10.3669***	-10.3517***	-8.7498***
	(1.0790)	(1.0966)	(1.2824)	(1.8580)
Observations	4,079	4,079	4,079	4,079
R-squared	0.7362	0.7389	0.7329	0.7342
Model Significance	0.0000	0.0000	0.0000	0.0000
Control for Contiguity	Yes	Yes	Yes	Yes
Control for Common Language	Yes	Yes	Yes	Yes
Control for Colonial or Dependency Relationship	Yes	Yes	Yes	Yes
Control for Sibling Relationship	Yes	Yes	Yes	Yes
Control for Both WTO Member	Yes	Yes	Yes	Yes
Control for Both EU Member	Yes	Yes	Yes	Yes
Control for RTA	Yes	Yes	Yes	Yes

Notes: *** p<0.01, ** p<0.05, * p<0.1. Robust clustered standard errors in parentheses. This table contains the results of the PPML estimations of earlier models with the AGENTA gravity dataset. Model (1) is a PPML estimation which includes the 65+ dependency ratio. Model (2) is a PPML estimation which includes the 65-69 and 70+ dependency ratios. Model (3) is a PPML estimation which includes the 65+ consumption ratio. Model (4) is a PPML estimation which includes the 65-69 and 70+ consumption ratios.

Table D 6. AGENTA gravity dataset analyses with alternative IV combinations

VARIABLES	Model 1	Model 2	Model 3	Model 4
Log of 65-69 Dependency Ratio Importer	-1.3815***	-1.4726***		
	(0.4460)	(0.3337)		
Log of 70-74 Dependency Ratio Importer	0.1648			
	(0.4992)			
Log of 75-79 Dependency Ratio Importer	1.8259***			
	(0.6243)			
Log of 80+ Dependency Ratio Importer	-0.1770	1.4468***		
	(0.4696)	(0.2581)		
Log of 65-69 Consumption Ratio Importer			1.3491***	-0.1984
			(0.4382)	(0.3409)
Log of 70-74 Consumption Ratio Importer			-3.5028***	
			(0.5605)	
Log of 75-79 Consumption Ratio Importer			3.5285***	
			(0.5498)	
Log of 80+ Consumption Ratio Importer			-1.6623***	-0.6247***
			(0.3080)	(0.1881)
Log of GDP Exporter	1.2652***	1.2663***	1.2652***	1.2669***
	(0.0172)	(0.0173)	(0.0173)	(0.0173)
Log of GDP Importer	1.2194***	1.1459***	1.3065***	1.2860***
	(0.0349)	(0.0319)	(0.0261)	(0.0260)
Log of Distance	-0.9208***	-0.9354***	-0.9356***	-0.9333***
	(0.0585)	(0.0586)	(0.0582)	(0.0584)
Constant	-21.7058***	-22.1395***	-28.3013***	-30.0849***
	(1.1052)	(1.0674)	(1.6208)	(1.6000)
Observations	4,079	4,079	4,079	4,079
Adjusted R-squared	0.7261	0.7246	0.7278	0.7245
Model Significance	0.0000	0.0000	0.0000	0.0000
Control for Contiguity	Yes	Yes	Yes	Yes
Control for Common Language	Yes	Yes	Yes	Yes
Control for Colonial or Dependency Relationship	Yes	Yes	Yes	Yes
Control for Sibling Relationship	Yes	Yes	Yes	Yes
Control for Both WTO Member	Yes	Yes	Yes	Yes
Control for Both EU Member	Yes	Yes	Yes	Yes
Control for RTA	Yes	Yes	Yes	Yes

Notes: *** p<0.01, ** p<0.05, * p<0.1. Robust clustered standard errors in parentheses. Model (1) is an OLS regression model which includes dependency ratios of all four age groups. Model (2) is an OLS regression which includes dependency ratios for the 65-69 and 80+ age groups to reduce multicollinearity concerns. Model (3) is an OLS regression model which includes consumption ratios for all four age groups. Model (4) is an OLS regression model which includes consumption ratios for the 65-69 and 80+ age groups to reduce multicollinearity concerns.

Table D 7. Alternative disaggregated analyses with all consumption ratios

VARIABLES	Model 1 Food	Model 2 Non-Alc. Beverages	Model 3 Alc. Beverages	Model 4 Tobacco	Model 5 Apparel	Model 6 Footwear	Model 7 Appliances	Model 8 Furniture	Model 9 Medicine	Model 10 Fuels	Model 11 Vehicles	Model 12 Other Trans. Equip.	Model 13 Telecomm. Equip.
Log of 65-69 Consumption Ratio Importer	0.4003	2.8529**	0.0173	-2.8645**	2.7351***	2.3162**	2.5157***	0.1074	0.4756	1.3418	-0.9885	-0.8035	1.9611**
	(0.5749)	(1.1962)	(0.9299)	(1.4399)	(0.6941)	(0.9890)	(0.5750)	(0.7572)	(0.8828)	(1.3660)	(0.7551)	(1.1577)	(0.8808)
Log of 70-74 Consumption Ratio Importer	0.1363	-0.3112	-0.4421	-7.1462***	-4.6162***	-6.1802***	-1.4549**	-0.3389	0.4844	-1.9017	1.8756**	2.1754*	3.7732***
	(0.7522)	(1.4790)	(1.2608)	(1.6384)	(0.8517)	(1.1258)	(0.6702)	(0.8894)	(1.1369)	(1.5504)	(0.8028)	(1.2540)	(0.9994)
Log of 75-79 Consumption Ratio Importer	3.7462***	4.8147***	2.9552**	11.6341***	4.9606***	7.2495***	3.0380***	2.9164***	5.0736***	2.7713*	0.9402	1.4771	-1.0164
	(0.6734)	(1.4464)	(1.2213)	(1.6842)	(0.7814)	(1.0834)	(0.6872)	(0.9819)	(1.0387)	(1.5382)	(0.8699)	(1.2186)	(0.9592)
Log of 80+ Consumption Ratio Importer	-3.3466***	-6.0991***	-2.0633***	-1.8875**	-2.2105***	-2.6028***	-1.9997***	-1.9105***	-4.1407***	-2.0513**	-0.7572	-2.4151***	-0.6482
	(0.3836)	(0.9207)	(0.6553)	(0.9278)	(0.4758)	(0.6830)	(0.3877)	(0.6319)	(0.6502)	(0.9660)	(0.5142)	(0.7677)	(0.5755)
Log of GDP Exporter	0.8827***	0.4768***	0.6438***	0.7094***	1.0321***	0.8602***	0.9482***	1.0385***	0.8337***	0.8451***	1.0070***	1.0575***	0.8673***
	(0.0377)	(0.0671)	(0.0565)	(0.1039)	(0.0422)	(0.0609)	(0.0392)	(0.0567)	(0.0536)	(0.0787)	(0.0477)	(0.0689)	(0.0481)
Log of GDP Importer	1.1089***	1.0913***	1.3816***	0.7779***	1.2626***	1.4384***	1.0656***	0.8643***	1.3194***	1.0280***	1.2463***	1.3679***	0.8335***
	(0.0426)	(0.0853)	(0.0596)	(0.1110)	(0.0443)	(0.0645)	(0.0466)	(0.0621)	(0.0600)	(0.0789)	(0.0493)	(0.0737)	(0.0517)
Log of Distance	-0.8888***	-1.0047***	-0.1796	-0.6557**	-1.3814***	-1.6706***	-1.4795***	-1.6191***	-0.7584***	-2.0022***	-1.6996***	-1.2256***	-1.4085***
	(0.1320)	(0.1934)	(0.1976)	(0.2527)	(0.1717)	(0.1972)	(0.1446)	(0.1876)	(0.1591)	(0.2502)	(0.1764)	(0.2369)	(0.1796)
Constant	-9.6803***	-9.7489**	-19.3177***	-10.6723*	-10.9094***	-11.2405***	2.5308	-4.1532	-9.2568***	-5.0884	-3.6735	-18.9150***	18.8567***
	(2.3423)	(4.6271)	(3.7729)	(5.7899)	(2.3523)	(3.9924)	(2.2327)	(3.9204)	(3.3771)	(5.3201)	(3.7119)	(4.5052)	(3.4024)
Observations	596	464	540	388	593	558	596	585	575	529	591	505	595
Adjusted R-squared	0.7555	0.4664	0.5643	0.3064	0.7386	0.6313	0.7554	0.6010	0.5801	0.4867	0.7079	0.5561	0.6140
Model Significance	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Control for Contiguity	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control for Common Language	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control for Colonial or Dependency Relationship	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control for Sibling Relationship	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control for Both WTO Member	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control for Both EU Member	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control for RTA	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: *** p<0.01, ** p<0.05, * p<0.1. Robust clustered standard errors in parentheses. The estimation in this table is the most complete specification, with the 65-69, 70-74, 75-79, and 80+ consumption ratio of the importer. It is a regression model without fixed effects. Model (1) estimates the model for the *Food and live animals* industry. Model (2) estimates the model for the *Non-alcoholic beverages* industry. Model (3) estimates the model for the *Alcoholic beverages* industry. Model (4) estimates the model for the *Tobacco and tobacco manufactures* industry. Model (5) estimates the model for the *Articles of apparel; clothing accessories* industry. Model (6) estimates the model for the *Footwear* industry. Model (7) estimates the model for the *Electrical machinery, apparatus and appliances, and electrical parts thereof* industry. Model (8) estimates the model for the *Furniture and parts thereof* industry. Model (9) estimates the model for the *Medicinal and pharmaceutical products* industry. Model (10) estimates the model for the *Mineral fuels* industry. Model (11) estimates the model for the *Road vehicles* industry. Model (12) estimates the model for the *Other transport equipment* industry. Model (13) estimates the model for the *Telecommunications and sound-recording and reproducing apparatus and equipment* industry.

Table D 8. Alternative disaggregated analyses with 65-69 and 80+ consumption ratios

VARIABLES	Model 1 Food	Model 2 Non-Alc. Beverages	Model 3 Alc. Beverages	Model 4 Tobacco	Model 5 Apparel	Model 6 Footwear	Model 7 Appliances	Model 8 Furniture	Model 9 Medicine	Model 10 Fuels	Model 11 Vehicles	Model 12 Other Trans. Equip.	Model 13 Telecomm. Equip.
Log of 65-69 Consumption Ratio Importer	0.9165*	3.0832***	0.1366	-4.6485***	0.7642	-0.3192	2.0604***	0.2306	1.2942*	0.5632	0.1540	0.4880	3.9308***
	(0.4920)	(0.9282)	(0.7421)	(1.2248)	(0.5728)	(0.7689)	(0.4727)	(0.6460)	(0.7348)	(1.0692)	(0.6684)	(0.9491)	(0.7741)
Log of 80+ Consumption Ratio Importer	-0.7509***	-2.8188***	-0.2219	3.2548***	-0.6230**	-0.0270	-0.4960**	-0.0652	-0.4772	-0.8989	0.6071	-0.5549	0.1127
	(0.2584)	(0.6074)	(0.4101)	(0.7128)	(0.2953)	(0.4270)	(0.2495)	(0.4132)	(0.4242)	(0.5855)	(0.3707)	(0.5100)	(0.3898)
Log of GDP Exporter	0.8757***	0.4648***	0.6375***	0.6624***	1.0290***	0.8518***	0.9451***	1.0312***	0.8185***	0.8433***	1.0025***	1.0486***	0.8624***
	(0.0398)	(0.0673)	(0.0577)	(0.1097)	(0.0438)	(0.0624)	(0.0397)	(0.0564)	(0.0542)	(0.0788)	(0.0474)	(0.0702)	(0.0489)
Log of GDP Importer	1.0742***	1.0156***	1.3527***	0.5878***	1.2307***	1.3850***	1.0415***	0.8381***	1.2610***	1.0107***	1.2317***	1.3439***	0.8308***
	(0.0422)	(0.0794)	(0.0581)	(0.1079)	(0.0436)	(0.0629)	(0.0457)	(0.0611)	(0.0581)	(0.0784)	(0.0484)	(0.0744)	(0.0516)
Log of Distance	-0.9529***	-1.0427***	-0.2139	-0.6324**	-1.3201***	-1.5982***	-1.4817***	-1.6516***	-0.8510***	-1.9979***	-1.7699***	-1.3272***	-1.5031***
	(0.1389)	(0.2050)	(0.1966)	(0.2813)	(0.1667)	(0.1938)	(0.1442)	(0.1861)	(0.1790)	(0.2470)	(0.1798)	(0.2476)	(0.1811)
Constant	-9.9747***	-9.9185**	-19.5750***	-7.8534	-13.3756***	-14.5859***	1.5723	-4.7729	-9.3330***	-6.4265	-2.9664	-18.2693***	20.5766***
	(2.3921)	(4.8421)	(3.8920)	(5.9309)	(2.4240)	(3.9930)	(2.3087)	(4.0328)	(3.5681)	(5.2711)	(3.8002)	(4.6262)	(3.5023)
Observations	596	464	540	388	593	558	596	585	575	529	591	505	595
Adjusted R-squared	0.7316	0.4433	0.5560	0.2435	0.7251	0.6079	0.7487	0.5928	0.5452	0.4858	0.7010	0.5458	0.6028
Model Significance	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Control for Contiguity	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control for Common Language	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control for Colonial or Dependency Relationship	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control for Sibling Relationship	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control for Both WTO Member	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control for Both EU Member	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control for RTA	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: *** p<0.01, ** p<0.05, * p<0.1. Robust clustered standard errors in parentheses. The estimation in this table is the most complete specification, with the 65-69 and 80+ consumption ratio of the importer. It is a regression model without fixed effects. Model (1) estimates the model for the *Food and live animals* industry. Model (2) estimates the model for the *Non-alcoholic beverages* industry. Model (3) estimates the model for the *Alcoholic beverages* industry. Model (4) estimates the model for the *Tobacco and tobacco manufactures* industry. Model (5) estimates the model for the *Articles of apparel; clothing accessories* industry. Model (6) estimates the model for the *Footwear* industry. Model (7) estimates the model for the *Electrical machinery, apparatus and appliances, and electrical parts thereof* industry. Model (8) estimates the model for the *Furniture and parts thereof* industry. Model (9) estimates the model for the *Medicinal and pharmaceutical products* industry. Model (10) estimates the model for the *Mineral fuels* industry. Model (11) estimates the model for the *Road vehicles* industry. Model (12) estimates the model for the *Other transport equipment* industry. Model (13) estimates the model for the *Telecommunications and sound-recording and reproducing apparatus and equipment* industry.