The Effects of Population Aging on Economic Structure*

Jeffrey B. Nugent
University of Southern California
Los Angeles, Ca. 90089-0253

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Abstract

Virtually all countries of the world are either already going through a process of aging or are expected to do so in the near future. Once those which have not yet started that process begin to do so, they are expected to do so exceptionally rapidly. While numerous effects of population aging have been examined, one which has largely been ignored is the effect of population aging on economic structure. An understanding of these effects can be quite important in order to design mechanisms and policies for mitigating the foreseen adverse effects of population for growth and prosperity. This paper examines the determinants of the sectoral composition of output. While considering the traditional determinants of productive structure, such as population size, income per capita, resource endowments and technological change, the focus of this paper is on the effects of the age composition of the population. The model is estimated on the basis of panel data at five year intervals over the period 1960-2005 from each of the following samples: (1) about 100 countries, (2) a smaller sample of OECD countries for more detailed service sectors and (3) the 50 states in the United States. Several different specifications of the model are estimated and with several different estimation techniques. The age structure of population measures are shown to have significant effects on productive structure in most sectors, sometimes positive and sometimes negative. Finally, the paper attempts to simulate likely changes in productive structure attributable to projected changes in the age composition of the population over the next half century for each of several different types of economies.

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1. Introduction

The effects of population aging are myriad and potentially very important. Even though aging has thus far largely been confined to highly developed countries, it has also been occurring in several developing countries whose fertility rates began to decline some time ago. As noted in an important entry in the *Encyclopedia of Population*, "this pattern is expected to continue over the next few decades, eventually affecting the entire world" (Gavrilov and Heuveline, 2003, p 32). Moreover, as shown in Figure 1 (from Harper, 2006), aging (defined by the doubling of the share of the population aged 65 in the total population) is expected to occur much more rapidly in developing countries than it did in highly developed countries. For example, whereas it took well over 100 years for the share of the 65+ population in the total population to double in France, it took only 30 years for this to happen in Japan and is expected to take only a little over 20 years for this to happen in Colombia, Brazil, Thailand and Tunisia.

The extent of the aging problem is often identified in terms of the Potential Support Ratios (PSR) defined as the ratio of the population aged 15-64 to the number of persons aged 65 and older. For example, if future fertility levels should remain where they are today and life expectancy continues to rise, the PSRs may be expected to fall from about 4 for Europe as a whole in 2000 to between 1.4 for Southern Europe and 2 for Northern Europe by 2050. Italy is already experiencing an absolute decline in its population aged 15-64. Japan, Korea, China, Taiwan, Singapore, and many other highly populated countries are in varying stages of the same changes with populations expected to peak between now and 2040.[1] As a result, unless major adjustments are made, population aging is believed to threaten the viability of both traditional systems of old age support through children (in developing countries) and the modern state- and insurance-based health care and social security systems (in developed countries).

[1] See for example the various median variant projections of The United Nations (2005) for these countries.

Among the actual or foreseen adverse effects of population aging are those on labor force participation rates, the quality of human capital, labor productivity, household saving and public saving rates, the rates of capital formation and technological change. As a result of these various effects, population aging is widely believed to pose a very serious challenge to the sustainability of economic growth in many developed countries over the next couple of decades and perhaps of the rest of the world soon thereafter.[2]

Thanks to the ever-improving comparative data on people in different age groups in each of several different periods of time, and in some cases on people in different birth cohorts over time, many of these effects of population have been analyzed. As a result, the consequences of population aging for insurance and asset markets (including the composition of physical and financial assets), the relative prices of different goods and services, international capital movements, household living arrangements, housing, and various other forms of social and political behavior have been explored, both theoretically and empirically, even if not with great precision and not without controversy.

For the most part, however, each one of these effects has been examined within macroeconomic or alternatively micro-level frameworks that abstract away from economic structure and changes therein over time. Nevertheless, as will be explained below, the strength and direction of many of these effects may be conditional on the existing economic structure. This paper, therefore, has two objectives: (1) to explain why these effects of population aging on economic structure may be important in analyzing the effects of aging on several of the other

[2] Indeed, the sense of alarm is so great that many countries are considering radical changes in policy, such as turning from policies favoring fertility reduction to fertility encouragement or encouraging immigration on a massive scale. For example, even tiny Singapore is considering a plan to double the population by about 2025 largely through immigration and to develop sectors of the economy like tourism for the specific reason that it may be able to make use of Singapore's rapidly growing over 65 population (Tan Khee Giap,(2006).

forms of behavior identified above, and (2) to demonstrate the existence and likely character of the effects of aging on economic structure.

In examining the effects of population aging on economic structure, we view population aging as but one of several components of the age structure of the population, each of which may have distinct effects on the productive structure (i.e., the sectoral composition) of the economy. Our presentation is organized as follows.

Section 2 takes up the first objective, i.e., to identify and explain several reasons for believing that it may be important to consider the sector composition of output in examining the other effects of population aging mentioned above. Section 3 provides a brief review of some of the relevant literature on the determinants of the structure of employment and productive activity. This literature has largely ignored the effects of aging and other demographic factors. Section 4 starts on the second objective by developing our hypotheses concerning how the supply and demand sides of different sectoral outputs may be affected by the age distribution of the population. It goes on to formulate the empirical model, identify the measures and data used to estimate it, and also identify the estimation method. Section 5 presents the empirical results on the determinants of the shares the different sectors in GDP at various levels of sector aggregation. It makes use of different samples, two international ones and another based on states within the United States. Finally, Section 6 summarizes our results, simulates the likely effects of population aging on the sectoral composition of output, and draws some inferences for policy.

2. Why Is It Important to Understand the Effects of Population Aging on Economic Structure?

It is generally agreed that the effects of aging on economic growth are realized through labor force participation and hours of labor supplied, private and public saving, labor skills and

productivity, capital accumulation, factor proportions, factor prices, financial instruments and their comparative rates of return, and international labor and capital flows. We suggest that in each such case, the effects realized may depend on the structure of the economy. Therefore, one may not be able to fully evaluate past influences or anticipate any or all of these future effects without understanding the effects of aging on the productive structure of the economy.

First, with respect to labor supply effects, it has been amply demonstrated that both the ability and willingness to work of older persons depends very much on the nature of the job. Heavy physical activities are likely to be beyond the abilities of the vast majority of workers over 65 years of age. But, on the other hand, light work involving clerical or managerial tasks and operating simple machinery such as that used in agriculture or some services may be quite suitable to many older people. Those elderly persons with experience in computers and other forms of modern technology may be especially willing and able to continue working. Yet, since the occupational and activity mixes vary by industry, the effective labor supply of older workers over time may be depend heavily on economic structure and changes therein over time.

Second, and closely related to differences in labor force participation rates of older workers across sectors, are variations in their productivity relative to that of younger workers. Such differences may result from the physical and mental requirements of the activities themselves or in the frequently observed differences in rates of return to experience and education in different industries. In particular, rates of return to education are widely believed to be much greater in high technology sectors than in standard manufacturing and service sectors. But, in turn, the rates of return to education may be higher in the latter sectors than in agriculture. Once again, such differences imply that the sectoral distribution of production and employment will affect the effects of aging on future productivity and growth.

Third, both theory and empirical evidence show that saving rates depend on such things as the level of income (and wealth), the instability of income, position in the life cycle[3], and the potential vulnerability of one's job to layoffs (e.g., due to outsourcing and globalization). Each one of these characteristics, however, is likely to vary by sector. For example, wage rates are higher in some industries than others, but wage rates and employment levels may be subject to wider fluctuations in output and employment in some sectors than in others. Similar differences across sectors may apply to entrepreneurial income. Since mean retirement ages may vary considerably from one sector to another, the life cycle pattern of saving and consumption at the aggregate level will differ somewhat depending on the industry mix. Similarly, some sectors and occupations seem to be much more vulnerable to the threat of outsourcing and hence potential layoffs than others. For all these reasons, futures changes in structure of output are likely to have substantial effects on the importance and nature of the risk and uncertainty, and thereby future changes in savings rates.

Fourth, since different sectors have different factor intensities, changes in the sector mix of output can affect factor and asset prices and hence their effects on capital accumulation, fertility and international flows of capital and labor force growth. Similarly, since different sectors are characterized by differing degrees of competition and of product homogeneity/ heterogeneity, which in turn may vary in their requirements for legal institutions, financial markets and so on, for any given level of institutional development, the extent to which a country takes advantage of potential comparative advantage may depend on the sectoral composition of output.

Finally, there are numerous theories suggesting that certain sectoral output patterns (such as those giving rise to strong inter-industry linkages, intra-industry trade, learning by doing

[3] Campell and Mankiw 1989

effects, and in which R&D expenditures are common) are likely to be associated with higher rates of TFP growth than other sectoral output patterns.

For all these reasons, therefore, the implications of aging for economic growth are unlikely to be properly understood without first understanding how aging and other changes in the age structure of the population affect the sectoral composition of output. It is thus to the determinants of the sectoral composition of output that we now turn.

3. Some Relevant Literature on the Determinants of Productive Structure

Studies on the determinants of the productive structure of the economy have a rather long history, including those of both economic historians, such as those of the German historical school, Fischer (1939), Clark (1940), and especially Kuznets (1957, 1958, 1962, 1966), and development economists such as Chenery (1960), Chenery and Taylor (1968), Chenery et al (1974), Chenery, Robinson and Syrquin (1986). Many of these approaches viewed the output structure as changing systematically with the level of development. While some of these studies have been largely descriptive (tracing out changes in sector shares over time for individual countries), some of the more recent ones have estimated cross-sectional or panel regression models for the shares of each different sector in value added or employment. The explanatory variables in these models are typically GDP per capita, population size, and one or more measures of trade structure. A standard finding in the development literature is that the sector shares of GDP or employment in a given country follow a normal pattern (often nonlinear in form) as income per capita rises but that this normal pattern can also be affected by its population size and/or resource endowment (as reflected in share of exports and the commodity composition of exports). As a result, countries of different size and resource endowments may follow somewhat different normal growth patterns as income per capita rises. The rationale for

the patterns observed is primarily derived from income elasticities of demand at the household consumption level as reflected in the well-known Engel curves.

To our knowledge, none of these studies introduced the age distribution of the population as a determinant of economic structure. In recent years, however, at least at the descriptive level, more consideration has been given to demographic considerations. For example, with respect to the United States, Frey (1994) has noted that, as population has been aging, there has been increasing migration of the elderly to the "sun states" of Arizona, Florida, Oregon, and Nevada, with consequences for the productive structures of these states. This could imply changes in the sector distribution of state product or employment. At the same time, there has been migration of younger adults from the East to the West (especially to California, Oregon, Washington and Texas) implying some substantial changes in the age distribution of the population at the state or regional level. These changes also imply changing labor force participation rates by age, which in turn could affect both the supply of labor and the sectoral demand patterns of different states.

At the same time, there has been a considerable body of literature (e.g., Schulz et al 1991) showing that the elderly have different spending patterns than younger persons. For example for the United States, McConnel and Deljavan (1983) and Schulz (1991) have shown that households headed by elderly persons spend much more on housing, medical care, gifts and contributions than those headed by younger adults but less on transportation, apparel, and education, even after controlling for household size and income. These same studies have also shown the income elasticities of consumption spending to vary across these age groups. Explanations for these differences in consumption patterns across age groups and over time are believed to lie in marriage, child-bearing, retirement and/or relocation decisions.

Prompted by striking differences in the observed trends of the shares of primary and secondary sectors on the one hand and tertiary sectors on the other in total employment in Australia and Japan since 1960[4], Orzechowska-Fischer (2004) examines the contribution of population aging to these trends. She shows very considerable differences in the median age of those employed in different sectors and the trends therein. For example, in the primary sector the median age of workers was much higher and rose more sharply than in the secondary and tertiary sectors. Indeed, by 2000 the median age in Japan of those engaged in agriculture was 63 but only 45 in manufacturing and 43 in tertiary activities, and in Australia it was 45 in the primary sector, 39 in manufacturing and 38 in the tertiary sector. Also, even within the tertiary sector, she found considerable variation in median age, especially in Australia where it varied from 34 in wholesale and retail trade to 43 in electricity, gas and water. Similarly, she found sizable differences in the propensities to be employed at age 65 by industry. These were higher for those in primary activities in Japan than in any other industry. The same point concerning sectoral differences in the age structure of employment can be seen in Table 1. Note the extent to which the share of workers aged 50 and over of all employed persons in the sector varies both across sectors and countries. Yet, despite this essentially descriptive and anecdotal evidence, systematic analysis of the relation between aging and the sectoral composition of output or employment appears to be lacking.

4. Hypotheses, Empirical Specification, Data and Measurement

We suggest that population size and age structure can affect both the supply and demand sides of the market for each commodity/sector in the economy. In that way, the commodity or sectoral structure of the economy can be affected by changes in the age distribution of the population. For example, on the supply side, a sector like agriculture may be favored by a large

[4] The trends have been for the primary and secondary sectors to decline but the tertiary sector to rise.

share of young people (e.g., under the age of 15) in the population, since children can often be relatively more productive in such work through on the job training within farm families than in non-agricultural setting with more formal employer- employee relations. Also, laws and regulations restricting the supply of such child labor are less likely to be present or, if present, enforced in this sector and other rural activities. At the same time, on the demand side, a large share of children in the population may increase the demand for agricultural products relative to those of other sectors because of the relative importance of food in the consumption baskets of people at young ages. If so, the effects of a large share of children in the population on the share of agriculture could be positive via both the supply and demand sides of the market for such goods. The two effects would in this case be complementary to one another.

Similar positive complementarities might also be expected in the case of the share of the elderly in the population. For example, very similar arguments might apply to agriculture suggesting that a larger share of the elderly in the population would also be likely to raise the share of agriculture in aggregate economic activity. These effects might also be supplemented in certain situations by political economy considerations. For example in those developed and democratic countries like Japan, Western Europe and the U.S. where older people form a substantial share of the population, and as noted in Table 1 above, older workers form a relatively large share of the work force in agriculture, political pressure from these older voters might induce governments to provide more subsidies for this sector. If so, this would have the effect of increasing resource allocation to this sector relative to what it would be in the absence of the pressure and subsidies. Also, in certain services (e.g., tourism, travel services, community services and personal care) the share of the elderly in the population may have positive effects on both the supply side of output (because elderly persons may be better able to undertake jobs in

these services) and the demand side (because older persons devote larger percentages of their time and consumption expenditures to travel than younger people).

But, there may be other sectors where one could suppose that both the supply and demand side effects of a larger share of the elderly in the total population would be negative. For example, this could arise in many if not most manufacturing and construction sectors where the elderly might be much less able to work and unlikely to spend much on new housing or on consumer durables. The manufacturing sector, moreover, may have more stringent labor regulations and/or more comprehensive retirement programs which discourage the employment of persons over 65.

There may be still other sectors, however, where the different effects of shares of children or the elderly in the population may offset each other. For example, in the case of children, children may be less able to work in clothing factories (because of laws and regulations) thereby having a negative influence on the share of Wearing Apparel but Wearing Apparel might be relatively important in their consumption baskets, thereby having a positive influence. In the case of the elderly, printing and publishing could be a sector in which one might expect positive effects on the demand side but negative ones on the supply side or through political economy channels. Since in virtually all sectors there may well be at least some effects of population aging that may be positive and others that may be negative, in general both the direction and magnitude of the net effects have to be determined empirically.

As noted above, the second objective of the paper is precisely to examine the net influences of these supply and demand effects of changes over time and across countries in the population shares of different age groups while controlling for other determinants of the sectoral composition of output.

Our approach to accomplishing this second objective is to capture the effects of population aging on economic structure with a reduced form approach in which each sector's share of output is related to certain segments of the age structure of the population, while controlling also for a number of other relevant factors assumed to be exogenous to the determination of the sector shares. These include population size (and its square), the level of per capita income (and its square), the openness of the economy, the structure of exports (to reflect natural resource endowments), year dummies to capture the influence of sector-specific technology and taste changes, and the distribution of income (since for given income level both demand and supply patterns can also be influenced by distribution). In some specifications, we also include interaction terms between the age group shares and either their respective labor force participation rates or per capita income.

Many of the older studies on economic structure referred to in the previous section were cross-sectional. As such, especially since none of them included demographic variables, one can suspect that their results could be biased as a result of omitted variables that may be related to some of the included variables, introducing correlation between the errors and explanatory variables. While in principle much can be learned by studying such effects at the country level over time, for the most part, time series historical data, especially that on sector shares of output and the age structure of the population, are limited to a very few decades within which the age structure may vary only slightly. Since there is more variation in the relevant variables and more data available across countries than over time, but also considerable variation over time in at least some countries, this study uses the most complete panel data available across countries as well as across states in the US and over time. It also makes use of fixed effects estimation so as to mitigate the problems arising from the many other unobserved country characteristics.

The data on our dependent variables, the shares of sector value added in aggregate GDP (in current prices) come from different sources and with certain limitations in terms of sector comparability and country and time coverage. The greatest limitation is that the aggregation levels for which comparable data are available vary from country to country. For some countries for comparative purposes one has to settle on quite high levels of aggregation (e.g., single digit ISIC) whereas in other cases comparable data on output shares is available at the three digit level. Data for four global sectors ((1) Agriculture, (2) Mining, Manufacturing, and Utilities (MMU), (3) Construction and (4) Services and also for three somewhat more disaggregated sectors, namely, the division of the aggregate Services sector into three less aggregated ones, i.e., (5) Transportation, Storage and Communication (TSC), (6) Trade, and (7) Other Services, are obtained for the period 1970-2004 from the United Nations Industrial Development Organization (2004, 2006). The disaggregation of MMU into manufacturing as a whole (ISIC 300 and into 28 more specific sector shares (ISIC 311-390) in GDP is also available from the same source, though in a comparable manner for fewer countries. Finally, for OECD countries only, data on the shares of 11 more disaggregated service sectors[5] are obtained from the OECD (2001). Sources for sector shares in State Domestic Product for the US are given below.

Turning now to the measures of the explanatory variables, the data on both population and the age distribution of population (1950-2005 at five year intervals) are taken from the United Nations (2005). Three segments at the extremes of the age distribution are singled out (0-14, 65-74 and 75 and over). The first and last of these are generally outside the labor force except in certain circumstances identified in our hypotheses. The 65-74 age group varies more in its

[5] These are Wholesale and Retail Trade and Repair of Motor Vehicles (ISIC 50-52), Restaurants and Hotels (ISIC 55), Transport and Storage (60-63), Communications (64), Finance and Insurance Services (65-67), Real Estate and Business Services (70-74), Public Administration and Defense (75), Education (80), Health and Social Work (85), Other Community, Social and Personal Services (90-93), and Private Households with Employed persons ((95).

labor force participation across countries and sectors. Alternative estimates have also been obtained with the two older age groups aggregated into a 65+ group, which is especially desirable in those sectors with fewer available observations and where the shares of these two contiguous age groups may tend to move together across countries or over time. Data on labor force participation rates of those aged 65 and over are obtained from the International Labor Office. Since labor force participation data by both age group and industry is extremely limited, we use labor force participation of those aged 65 and over at the aggregate level as part of an interaction term with the age share of the population. The age group of those 15-64 for which labor force participation is typically at its maximum is the excluded group. Because the supply side effects of the shares of the 65+ age groups would be expected to be negative except in some of the special circumstances noted above, one might expect the effects of both the 0-14 and 65+ age groups to be generally negative. But since the dependent variables are sectoral shares of output, not all shares can decline when the shares of these age groups rise. Hence, a more mixed picture may be expected. Moreover, as suggested above, there is indeed good reason to believe that in certain sectors the demand – side effects of these age groups could be sufficiently strong as to bring about strong positive effects.

The data on real GDP per capita (at PPP prices) are taken from the Penn World tables and supplemented by data from the World Bank (2005). Both real GDP per capita and Population are used in their logarithmic form.

For our measure of trade-openness we use several different data sets to further extend the Sachs-Warner measure of trade openness (0 for "closed" and 1 for "OPEN"), that was already corrected and extended by Wacziarg and Welch (2003).[6] In extending each country's series

[6] Specifically, these authors defined a country as closed (i.e., open =0) if it had any one of the following: (1) an average tariff rate of 40 per cent or more, (2) non-tariff barriers covering 40 per cent or more of trade, (3) a

across time (wherever possible), for the most part we made use of additional raw data on each of the various components of the Sachs-Warner index, together with the same criteria for distinguishing between "OPEN" and "closed". In some cases, however, when the raw data was incomplete, we also made use of information available from similar indexes from the *Economic Freedom in the World* surveys published by the Fraser Institute (Gwartney, Lawson and Block, 2000) and openness measures from the Penn World Tables. We have extended the country coverage slightly based on additional country-specific information for several of the criteria when confirmed by extremely open ("Free") or closed ("Repressed") for relevant years in the "Trade Openness" component of the *Index of Economic Freedom* reports.[7]

Data for our measure of natural resource endowment, namely, the share of Agriculture, Minerals and Fuel in aggregate exports (ShareAMF), is taken from the United Nations Statistical Office and supplemented by data from World Bank (2005). Finally, the data on Gini coefficients are taken from several sources.(WIDER, Deininger and Squire, United Nations) Since the available data on Gini coefficients seldom coincide with the exact five year intervals for which the other data is available, we have used the closest available year and in some cases interpolated in between years from the corresponding country observations for an earlier and later year. Even so, the available observations on the Gini coefficients are considerably more limited than for all the other variables.

Due to the age-specificity of internal migration noted in Section 3, migration could play a more important role in affecting the sectoral composition of output within countries than

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black market exchange rate that is depreciated by 20 percent or more relative to the official exchange rate, (4) a state marketing agency or board for major exports, and (5) a socialist economic system (as defined by Kornai 1992). Rodrik and Rodríguez (2001) provide a critique of these efforts.

[7] Specifically, previously non-classified Bahrain, Iceland, Lebanon, Oman, Qatar and UAE are classified as "open" for some years based on scores of 1 ("Free") or at most 2 ("Mostly Free"), while Cambodia, Laos, Libya, Sudan and Suriname were classified as "closed" based on scores of 5 (Repressed) on the same Trade openness component of the index for some years.

between them. Hence, the results for states or regions within countries may differ from those obtained across countries and over time. For this reason, we also make use of panel data across states in the United States. The Gross State Product data and population and age distribution data for the U.S. are taken from U.S. Department of Commerce, Bureau of Economic Analysis, Regional Economic Analysis Division, (2006) and United States, Bureau of the Census, Census 2000, respectively.

As noted above, with each of the panel data sets, we have estimated the following model using both fixed effects and random effects:

$$Y_{it} = X_{it} \beta + \alpha_i + u_{it}$$

In the case of fixed effects, the parameters are estimated with OLS whereas for random effects, GLS estimates are used. Because of the relevance of numerous non-changing unobservables at the country or state levels (including differences across countries in the sector definitions), we focus almost exclusively on the fixed effects results.

5. Results

The results are divided into separate tables, Table 3 for the four global sectors and three subsectors of Services, Appendix A for total manufacturing and 28 subsectors of manufacturing, Appendix B for the 11 service sectors, and finally Table 5 for the age group share results for the United States. Table 4 contains the specific age share coefficients obtained from Table 3 and Appendices A and B. The first two of these tables are based on the full sample of international data from UNIDO, while the estimates of Appendix B are based on the more limited sample of OECD countries. Finally, Table 5 gives the results for the various sectors and subsectors using US data. In each case we present the results for several specifications, those in the first column in which nine explanatory variables are included and those in the second column in which the Gini

variable is excluded. The omission of the Gini measure of inequality is motivated by two considerations, first, its more limited data availability, thereby limiting the number of observations when it is included, and second, the undoubtedly lower quality of its measurement. In the remaining columns of each table, year dummies are included, interaction terms involving the 65+ age share. Finally, since the inclusion of this variable also limits the size of the data set, in the last column we use the same specification as in the fourth column of the table but with the smaller data set used in the next to last column.

We begin with the results for the four global sectors and three subsectors of Services given in Table 3. Given our focus on demographic effects, we start with the effects of the shares of population in the 0-14, 65-74 and 75+ (or simply 65+) age groups.

For the 0-14 share, the coefficients are negative and significant in most specifications in the Mining, Manufacturing and Utilities (MMU), Transportation, Storage and Communication (TSC), but positive and significant in Services, Other Services, and Trade. In the other Global sectors, the coefficients of this variable are statistically insignificant and often changing in sign from one specification to the other.

For the 75+ share, the coefficients are positive and significant once the year dummies are included in Agriculture and to a lesser extent Other Services and Trade but generally negative and often significant in MMU, Construction, TSC (once the year dummies are included).The effects of the 65-74 age share are positive and significant in most specifications for Services, Other Services and Trade but negative and often significant in all the other sectors. The coefficients of the interaction term involving 65+ Age share in the population and 65+ Labor Force Participation Rate are significant in only three cases, namely positive and significant for Construction, and negative and significant for Services and Trade.

Consistent with the earlier development literature, the effects of GDP per capita are in most cases nonlinear and significant. Notably, the effects of Log GDP per capita are of inverted-U shape in MMU, Construction, TSC, and Trade, but U-shaped in Agriculture, Services, and Other Services. On the other hand, the coefficients of Log Population are positive and significant in Agriculture (at least once the year dummies are included) and MMU, but negative and significant in the regressions for Services, Other Services, and Trade.

OPEN has significant negative effects on the shares of MMU and Construction but positive and significant ones for the shares of Services, Other Services, and Trade. Since these are estimated via fixed effects, these results are not the result of more developed countries having freer trade, smaller commodity-producing sectors and larger service sectors. As expected, the natural resource endowment measure (ShareAMF) has a large positive effect on the share of Agriculture but negative ones on the shares of MMU, Services, and Other Services.

The effects of income inequality (Gini) are positive and significant on the sector shares of Construction, Services and Other Services but negative on the shares of MMU and to a lesser extent Trade.

Taking together the effects of aging (captured by the shares of the 65-74 and 75+ age groups in the population), in the rather highly aggregated sectors in Table 3 indicates that effects are negative and significant for both age groups on the sector shares of MMU and Construction and positive and usually significant in Services (as a whole), and especially so in (the more narrowly defined) Other Services. In all the other sectors, the effects are more mixed, either positive for one subsgroup and negative for the other (as in Agriculture or Trade) or generally insignificant in both cases (as in TSC).

Next we turn to the results for the 28 more detailed manufacturing sectors for which the full results are given in Appendix A. Since these are all disaggregates of the Mining, Manufacturing and Utilities Sector (MMU) for which the results were given in Table 3, in general we can expect results similar to those for MMU. Because of the smaller number of observations available at these more disaggregated levels of industry, and the similarity in the effects of the shares of the 65-74 and 75+ age groups in the results for MMU in Table 3, in our empirical estimates for each of these 28 manufacturing sectors, we combine the two groups into a single 65+ age group.

The same is done for the 11 more disaggregated service sectors, the results for which are given in Appendix B. Although the samples used in this table are limited to OECD countries alone[8], instead of all countries in the previous tables, it is again instructive to compare these results to that for the aggregate Services sector in Table 3 above. Note that all three of the age groups of interest (0-14, 65-74 and 75+) had positive and significant effects on the share of Services in GDP in Table 3. Consistent with this, as indicated in Appendix B, both the 0-14 and 65+ age group shares have positive and significant coefficients on the sector shares of ISIC sectors 50-52, 60-63, 70-74, and 90-93. In addition, the 65+ age group share has generally positive and significant effects on the sector shares of ISIC sectors 75, 85 and 95. But, these same coefficients are negative and sometimes significant in ISIC sectors 55, 64, 65-67 and 80. From the full results of Appendix B it can also be seen that effects for other variables also vary in some cases quite considerably from one subsector to another. For example, OPEN has a positive and significant effect in only two subsector (ISIC 64 and 95) but insignificant ones in all the other subsectors. This contrasts with the fact that the coefficient of OPEN was consistently

[8] This implies that there should be less variation in the per capita income and age group shares in this sample than in the full sample used in Tables 3 and 4.

positive and significant in the Service, Other Services and Trade Sectors of Table 3. While AMF had negative and significant effects on all the service sector except Trade in Table 3, there are more such exceptions in the service subsectors of Appendix B.

Fewer such exceptions are observed in comparing the coefficients of the MMU aggregate in Table 3 with the Total Manufacturing and detailed manufacturing sectors of Appendix A. The coefficients of log Population are positive and those for OPEN and AMF negative almost without exception. For most of the subsectors also, the effects of the GDP per capita terms are similar in sign to those for MMU as a whole, i.e., positive for the linear term and negative for the quadratic term, respectively, reflecting the Inverted-U pattern mentioned above for this sector. Yet, there are a number of subsectors where these variables have no significant effects (Leather, Printing and Publishing, Plastics and Products, Other Chemicals, Petroleum Refining, Miscellaneous Petroleum and Coal Products. There are also four such subsectors, Industrial Chemicals, Other Chemicals, Machinery (Other than Electric) and Electric Machinery, where the signs of the coefficients of GDP per capita and its square are positive and negative, respectively. There are also a few cases (ISIC 331, 342 and 354) where the effect of Gini on the sector shares, is positive instead of negative as in the case of MMU in Table 3.

In Table 4 we present what we believe to be the most reliable and comparable estimates of the coefficients of the shares of the 0-14 and 65+ age groups in the population from Table 3 and Appendices A and B.[9] Even though as indicated above no constraints have been imposed to assure that the sum of the impacts across all sectors of these age groups are equal to zero, one can see that the relevant sums do approximate this condition.

The coefficient of the 65+ age groups for the aggregate MMU sector in the top part of Table 4 is negative and significant just as is the corresponding one for Total Manufacturing at the

[9] In some cases the coefficients given here are actually the averages of the estimates.

bottom of the detailed manufacturing sectors in the same table. Even the magnitudes of the two coefficients are quite similar. The table also shows that this coefficient is negative for 23 of these 28 manufacturing subsectors. Similarly, the coefficients of the 0-14 age group are negative for both MMU and Total Manufacturing and for 26 of the28 subsectors of manufacturing. The exceptions are ISIC 314, 323, 324, 354 and 355 in the case of the 65+ age group, and ISIC 323 and 354 for the 0-14 age group. For the manufacturing subsectors, we also present estimates of the coefficients of interaction term between the 65+ age group share and the 65+ activity rate. For 23 of these 28 sectors the signs of these coefficients are as expected positive, though in only about half these cases are they statistically significant.

Because of the fact that the sector shares are explained in tables 4 and 5 are much smaller than those of the more highly aggregated ones of Table 3, not surprisingly the magnitudes of the coefficients are generally smaller in these tables.

Finally, in Table 5 we present corresponding estimates of the effects of the 0-14 and 65+ age groups on sector shares for the United States, based on state-specific data on Gross State Product per capita, population and age distribution. These results offer the advantage of allowing migration, which in the case of migration across states in the US (as noted in Section 3 above) has been rather age-specific, thereby impacting on the age distribution at the state level to a greater extent than can be observed at the international level (for all but a very few of the generally very small countries). Since trade data and income inequality at the state level are not available, these regressions have not included measures for OPEN, Share AMF and Gini. For this reason, the results are not exactly comparable. Many of the sector definitions, moreover, are somewhat different than those in the seemingly rather similar sector names with results reported in the preceding tables.

Despite these caveats about differences, in several respects the results for comparable sectors are similar across the different data sets. For example, for Construction, Communications, and Transportation the direction and significance of the effects are identical. The world and US results are especially similar for the effects of the 65+ age group for those sectors that are defined most similarly in the two data sets (such as Agriculture and Manufacturing). But, for a few sectors there are some notable differences in the effects of at least one of the age group shares. For example, for the share of Agriculture, the effect of the 0-14 share was insignificant and sometimes negative in the specifications of Table 3 but positive and significant in Table 5. Similarly, for the Educational Services sector, the effect of the 65+ age share was insignificant with the international data of Table 3 but positive and significant in Table 5. Possible explanations for the latter difference are (1) that teachers and professors in the US are less subject to mandatory retirement rules than their counterparts abroad, (2) they more likely to remain in their communities on retirement than those in other occupations in the US, and (3) that more older citizens in the US are going back to school at Emeriti Colleges and computer literacy classes than in other countries. Another apparent difference is that the coefficient of the 65+ variable for Restaurants and Hotels was negative and significant in Table 4 but the corresponding one for Hotels and Lodging in Table 5 is positive and significant.

Table 5 also contains parameter estimates for a number of more narrowly defined services that did not appear in comparable form in any of the preceding tables. Many of these are of particular interest to aging. From the cross-state data for the US the 65+ share is shown to have positive and significant effects on the shares of each of the following sectors: Retail Trade, Depository Institutions, Non-Depository Financial Institutions, Insurance, Legal Services, Health Services, Personal Services, Private Households with employed persons, Social Services and

Hotels/Lodging, but negative or no effects on the shares of Wholesale Trade, Real Estate, Business Services and Government Services.

6. Projections and Conclusions

The results presented above lead to the following general conclusions.

First, for almost all sectors (all the global sectors, all the manufacturing sectors, and all but one of the eleven detailed service sectors (the single exception being Public Administration and Defense) in Table 4, and all but one of the sectors in Table 5 (based on US data), one or both of the age group variables are shown to have significant effects, either positive or negative. This is, of course, after controlling for various other factors deemed important for explaining changes in sector shares across countries and over time. In many of these sectors, these effects are relatively stable across the various specifications employed. Indeed, in most of these cases the results were also found to be robust to other specifications and estimation procedures used and available on request but not shown here. These included use of the absolute values of GDP per capita and population instead of their logarithmic transformations, the exclusion of observations for sector shares with zero values, the inclusion of additional interaction terms (between GDP per capita and the age groups) and in the case of estimation procedures, seemingly unrelated regressions (to allow correlation between the error terms across equations), and Random Effects (instead of Fixed Effects).

Second, however, there are also some sectors (for example Agriculture estimated with the full international sample, Education, Other Community and Social Services estimated with the OECD sample, and Mining estimated with U.S. data) where the magnitudes and even signs of the age group coefficients vary from one specification to another. These cases suggest areas which deserve more research into ways in which the patterns may vary by various other country

characteristics. In the meantime, considerable caution is needed about drawing any strong conclusions about the effects of aging or other demographic changes on the shares of these sectors in GDP. Some further discrepancies arise when one compares the corresponding coefficients of the age share variables for seemingly similar sectors in Table 4 (estimated with international data) with those for Education, Hotels and Lodging and Private Households in Table 5 (estimated with U.S. cross-state data). The latter estimates have the advantages of (1) being based on more homogeneous sectoral classifications and (2) better controlling for time-changing unobservables, and (3) of allowing to a greater extent for the influence of migration (some of which may be endogenous).

Third, our focus on the demographic influences that have been ignored in previous studies of economic structure should not be interpreted as denying the important role of per capita income and population size. Indeed, our results show these to be the dominant influences in quite a few sectors. So, too, natural resource endowments as reflected in the measure Share AMF and trade openness as reflected in OPEN are also shown to have significant and rather robust effects in almost all sectors. Finally, income inequality as captured by Gini has remarkably significant effects on the sector shares of some sectors.[10]

What the results for the demographic variables do not tell us is exactly why the patterns vary across sectors in they way they do. In Section 2 we offered some explanations for why the effects of the 0-14 and 65+ age groups on the shares of Agriculture and Services in GDP might be positive but those on construction and heavy manufacturing industries might well be negative.Note that in general the results are consistent with these conjectures. To some extent the

[10] For example, it has negative and significant effects on the sector shares of MMU and Trade in Table 3, manufacturing subsectors with ISIC codes 311, 313, 322, 324, 351, 355, 371, 381, 383, and 384 in the Appendix Tables, and Education in Table 5. But, at the same time, it has positive and significant effects on the shares of Construction, Services and Other Services in Table 3 and on the ISIC code sectors 331, 342 and 354 in the Appendix tables.

differences obtained from the different data sets can also help pin the explanation down. For example, since in the US older aged dependents are more likely to be dependent on purchased services (as opposed to those obtained from within the household and hence not recorded as part of gross state product in the services sector) than in other (especially developing) countries where dependents are more likely to live in extended households, this explanation would seem consistent with the finding that the positive effect of the 65+ age group share on the share of Hotels and Lodging from U.S. data in Table 5 is much stronger than the corresponding effect of this age group share on the share of Hotels and Restaurants in Table 4 based on international data. The same explanation would seem to apply in explaining the more positive effect of both the 0-14 and 65+ age group shares on the shares of Private Households with Employed Persons in Table 5 than in Table 4.

Given our focus on population aging, our final task is to make use of the available forecasts of the changing age structure of the population in different types of economies to simulate the magnitude and direction of changes in sector shares implied by our regression results. To that end, in Table 6 we present the estimated shares of the 0-14 and 65+ shares of the population in 2005 and in 2050 under both high and low variants of population growth. These projections are presented separately for developed countries, less developed countries, least developed countries[11] and for the United States. As noted in the table, these estimates are those of the United Nations (2005).

[11] These are the world's poorest countries in per capita income and include Afghanistan, Angola, Bangladesh, Benin,, Bhutan. Burkina Faso, Burundi, Cambodia, Cape Verde, Central African Republic, Chad, Comoros, Democratic Republic of Congo, Democratic Republic of Timor-Leste, Djibouti, Equatorial Guinea, Eritrea, Ethiopia, Gambia, Guinea, Guinea-Bissau, Haiti, Kiribati, Laos, Lesotho, Liberia, Madagascar, Malawi, Maldives, Mali, Mauritanea Mozambique, Myammar, Nepal, Niger, Rwanda, Samoa, Sao Tome and Principe, Senegal, Sierra Leone, Solomon Islands, Somalia, Sudan, Tanzania, Togo, Tuvalu, Uganda, Vanatu, Yemen and Zambia.

Not surprisingly, in all regions and by both sets of population growth projections, the shares of the 65+ share of the population are expected to rise by 2050. These increases are much larger under the low population growth variant (wherein fertility rates would be one percent lower than in the high growth variant) than under the high population growth variant. Indeed, note that, with the low population growth projection, the share of the 65 and over population would approximately double between 2005 and 2050 in the United States and developed countries as a whole, somewhat more than double in the least developed countries (though from a low base) and approximately triple in less developed countries.

Note, however, that for the 0-14 age share, even the direction of its projected change depends rather critically on the fertility assumption. This is true for all regions except the least developed countries (where the 0-14 share is expected to fall irrespective of the fertility assumption).

The projected changes in each of the two age group shares for each region and population growth scenario between 2005 and 2050 are then multiplied by the estimated values of the corresponding sector-specific coefficients in Table 4 (based on the international panel data) for all regions except the United States. The results for developed countries are given in Part A of Table 7. The results generated in a similar way for less developed and least developed countries are given in parts B and C of the same table. In the case of the United States, the coefficients used are those based on the cross-state panel data presented in Table 5. The resulting sectoral change projections according to the low and high population growth variants for the United States are given in Part D of Table 7.

In thinking about how to interpret these results, one should consider that these calculations are based exclusively on the projected changes in the age composition of the

population. In other words, the likely (or even assumed) changes in the size of the population and income per capita are ignored in these calculations. Also ignored are the effects of possible changes in factor endowments, income inequality and trade openness which were found to exert statistically significant influences on the shares of most sectors of the economy in the preceding analysis. In other words, these are by no means the most well-informed projections of the changes in sector shares of GDP between 2005 and 2050. What they represent, however, is the result of the most straight forward way of assessing the effect of changes in the age composition on sector shares of GDP.

Given that in all regions and by both population growth scenarios, the shares of the 65+ population are expected to increase, the effects of these projected changes on the sector shares are the easiest to interpret. Projected aging of the population, therefore, is expected to raise the share of agriculture in GDP in all regions by somewhere between 1.5 percent (for the least developed countries with the high population growth variant to 8.9 percent (for the developed countries under the low population growth variant).[12] The effects on services as a whole are also expected to be positive in all cases and generally larger in magnitude than for those on the agriculture share. These positive changes on agriculture and services resulting from aging are almost exactly offset by negative effects on the shares of construction, mining and manufacturing. Consistent with the variability in the net direction and magnitude of the effects of the 65+ age share from one subsector of services to another, there are substantial differences across subsectors of services in the effects of this variable on sector shares. For example, in developed countries where the largest increases in aging population are expected, according to the low

[12] In reality, the share of agriculture can be expected to decline over the period from now until 2050 in all regions due to the positive negative effects on the share of agriculture associated with rising income and perhaps declining AMF shares. As noted above, to focus on the influence of the age structure of the population, these influences have been ignored in these calculations. The calculation suggests merely that agriculture's share is expected to be these percentages larger than they would be without the changes in age structure.

variant of population growth, the change is expected to raise the share of ISIC 70-74 by over 10 percent of GDP and that of ISIC 50-52 by 6 percent but to lower those of ISIC 55 and 65-67 by over 2 percent and 4 percent of GDP, respectively.

The effects of the expected changes in the 0-14 age group on sector shares vary more from one region to another and from one population growth variant to another. They are also generally smaller in magnitude than for changes in the 65+ age group shares. In this case the effects are generally largest in the least developed countries under the low growth variant, with the predicted decline in the 0-14 age share expected to reduce the shares of ISIC 50-52 by over 10 percent and that of ISIC 70-74 by over 6 percent but to raise that of ISIC 55 by 13.6 percent.

Even though these projected changes in sector shares are all ones that will occur only gradually over the next several decades, as noted above, for all regions the projected changes in the sectoral shares of output are by no means small. In Section 2, we identified several reasons why changes in sectoral shares may be important. These had to do with the various potentially important links between sectoral composition and growth, including those through labor supply of older persons, the relative productivities of older and younger workers, savings rates via sectoral variations in the magnitude of economic fluctuations and hence uncertainty, linkages and externalities, differential importance of learning by doing. Since different sectors also have differing factor proportions, and different mixes of skilled and unskilled labor, changes in the sectoral composition of output can also affect income distribution. Since all these serve as important links to economic growth, it is clear that our ability to understand the implications of population for growth will not be complete until these effects on the sectoral composition of GDP are taken into consideration.

One can certainly think of other ways in which these sectoral change implications may be of use. For example, they might be of use in planning infrastructural developments, in manpower or educational planning and in considering the implications for future trading patterns.

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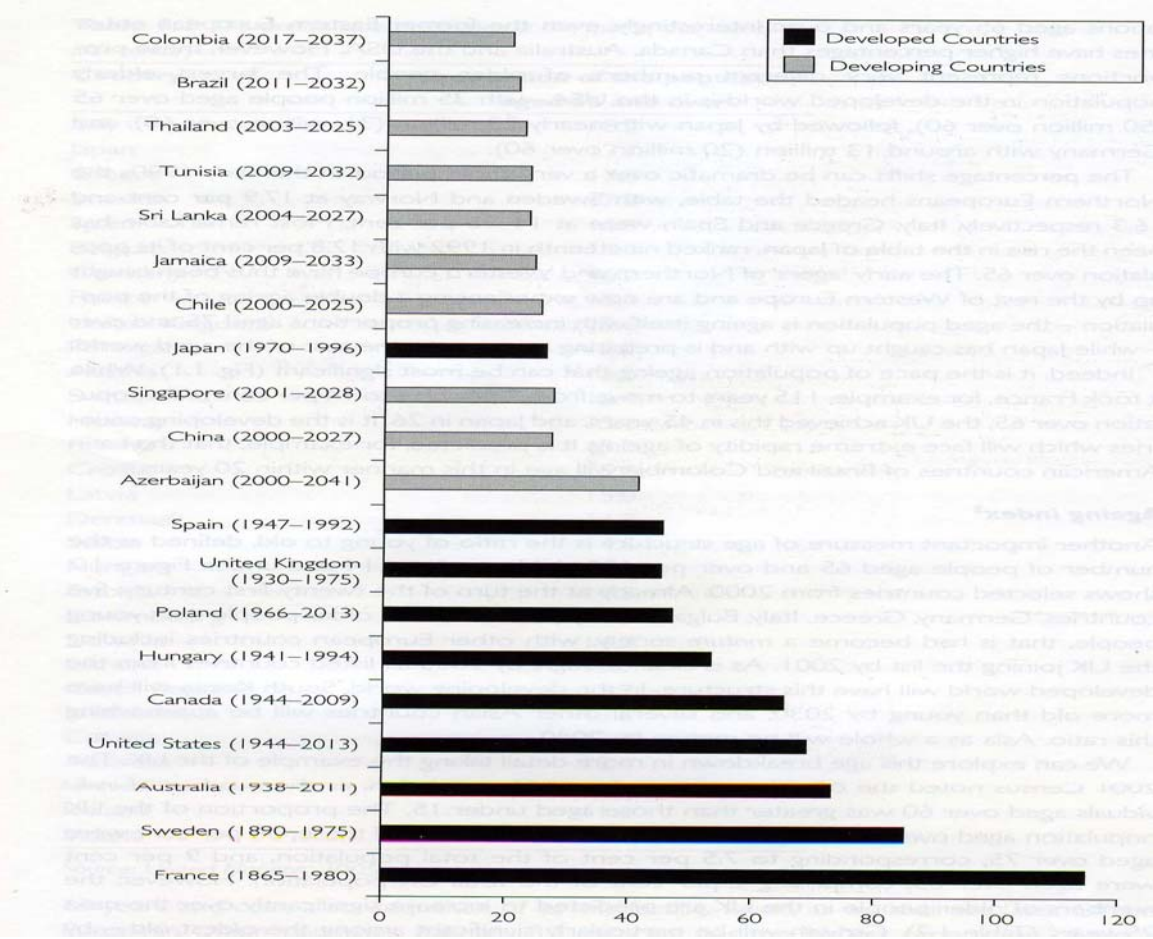
Figure 1

Years Required for Population Over 65 to Rise from 7 to 14% of Total Population



Source: Harper, Sarah. *Ageing Societies*. New York: Oxford UP, 2006.

Table 1

Older Workers (50+) As a Share of All Employed Persons in Each Industry (2002-2004)

Industry	USA	Japan	Korea	Finland	Norway	Denmark[a]	Australia[a]
Agriculture, forestry, fishing	40.1[b]	76.7	72.6	38[b]	36.4[b]	21	26.5
Mining	27.7	40	38.9	35[l]	27.2[o]	25.5 [o]	20
Construction	21.5	39.8	21.9	26.5	24.8	26	18
Manufacturing	27	36.9	15.1	24.4			21
Wholesale and retail trade	24.1	35.15[d]	19.5	22.8	20.9	21	18
Utilities		26.5[e]	9.6[h]				27[h]
Transportation and communication	31.5[c]	36.7	21.2	24.8[m]	24[m]	31 [m]	25[s]
Financial Activities	28.5	34.4	9.4[i]	24.9[n]	23.6[p]	24[n]	19[i]
Professional and business services	25.7	29.4	27.3[j]				23[j]
Educational and health services	30.9					32[r]	30.5[t]
Leisure and hospitality	15.4	35.3[f]	19.5[k]	17.1[k]		15 [k]	14[k]
Public administration	32.3	28.1[g]		28.9	30.2 [q]	38	30
Other services	29.7	35.6	18.3	26			23

Notes: (a) men 50-64 only, estimated from graph. (b) and hunting. (c) transportation and utilities. (d) average of wholesale and retail. (e) public utilities. (f) food and drinking places. (g) other government services. (h) electricity, gas and water. (i) finance and insurance. (j) real estate and business service. (k) hotels and restaurants. (l) and quarrying, electricity, gas, and water supply. (m) and storage. (n) and real estate. (o) and quarrying, manufacturing, electricity, gas, and water supply. (p) and real estate and business. (q) and education, health, and social work. (r) average of education, health, and social work. (s) average of transportation, communication, and storage. (t) average of health, education, and community services.

Source: *Ageing and Employment Policies*. OECD. Paris: OECD, 2005.

Table 2 Descriptive Statistics

Explanatory Variables International

	Obs	Mean	Std. Dev.	Min	Max
Population	32234	32831.25	117615.7	2	1315844
GDP Per Capita	27870	4859.388	7859.318	46.8	68800
0-14Share	30678	0.350434	0.1020811	0.1375874	0.5176237
65-74 Share	30678	0.0416278	0.0241691	0	0.1085217
75+ Share	30678	0.0225396	0.0187922	0	0.0930749
65+ Share	30678	0.0641675	0.0423816	0	0.1996798
Gini All	20909	39.72281	10.20988	16.63	73.9
Open	26649	0.5433337	0.4873631	0	1
Share AMF	14688	0.2800354	0.273368	0	1

Dependent Variables Sector Shares International

Agriculture	1271	20.1336	17.0420	0.0681	81.49607
Mining, Manufacturing, and Utilities	1268	23.3301	12. 4601	1.0998	77.07809
Construction	1272	6.0085	2.8618	0.4117	40
Services	1276	51.13521	14.65378	10.74463	88.46073
Trade	1265	15.3604	6.1150	1.8579	41.17647
Transportation	1269	7.5546	3.6919	0.4587	33.85226
Other Services	1265	28.2327	11.1063	1.5100	71.05972

Manufacturing Sectors Shares International

Food Products 311	621	2.4683	1.8329	9.55e -09	14.3
Beverages 313	593	0.9776	1.0801	9.09e -10	12.1
Tobacco 314	556	0.5177	0.5175	0	3.67
Textiles 321	612	1.1410	1.1441	4.55e-09	9.35
Wearing Apparel 322	561	0.6651	1.0792	4.09e-09	8.5
Footwear 323	514	0.1768	0.2066	1.25e-08	1.66
Leather Products 324	533	0.1357	0.3938	4.55e-10	8.38
Rubber Products 355	536	0.2583	0.2494	1.36e-09	1.41
Wood Products 331	600	0.4371	0.4510	1.34e-09	2.44
Furniture 332	556	0.2626	0.2572	9.09e-10	1.7
Paper and Products 341	589	0.5474	0.7069	2.27e-09	6.27
Printing 342	568	0.5909	0.4865	1.36e-09	3.36
Pottery, China 361	489	0.1706	0.3701	3.18e-09	5.45
Glass and Products 362	476	0.1493	0.1255	6.25e-09	0.818
Plastic Products 356	513	0.3431	0.2849	1.82e-09	2.19
Other Non-Metals 369	546	0.6644	0.5961	2.50e-08	9.45
Industrial Chemicals 351	592	0.8024	1.0417	1.59e-08	12.5
Other Chemicals 352	557	0.9415	1.7996	5.62e-08	23.6
Petroleum Refining 353	436	1.0547	1.5311	2.50e-08	10.3
Misc. Pet. and Coal Prods. 354	301	0.0811	0.1304	9.52e-09	1.71
Iron and Steel 371	499	0.9184	1.8435	9.55e-09	23.5
Nonferrous Metals 372	418	0.4345	0.8563	3.75e-08	8.57
Fabricated Metal Products 381	593	0.9181	0.9277	3.75e-08	7.15
Machinery Non-electric 382	538	1.0327	1.3977	7.27e-09	10.2

Machinery Electric 383	557	1.1262	1.5334	5.91e-09	9.45
Transport Equipment 384	552	0.9641	1.0245	5.00e-09	7.52
Other Manufactures 390	562	0.2403	0.4129	8.10e-08	4.5
Professional Instruments 385	439	0.2470	0.4478	2.27e-09	3.46
Total Manufacturing	611	16.24936	10.12165	7.91e -08	91.8

Service Subsectors Shares International OECD

Communication	85	2.11	0.5762	0.0068636	0.0326793
Education	89	4.001	1.407	0.0006399	0.0622404
Financial	99	4.982	2.3868	0.0095491	0.2111837
Health Services	91	4.603	2.094	0.0064223	0.0906619
Motor Repair and Sales	99	12.375	2.78046	0.0881488	0.2047972
Other Community Services	91	3.475	2.063	0.0178464	0.1147191
Private Households	68	0.239	0.20134	5.88e -06	0.0098122
Public Administration	94	6.584	2.85578	0.0256752	0.1510223
Real Estate	99	12. 579	4.60608	0.0343754	0.223931
Hotels and Restaurants	93	2.12212	1.070	0.006081	0.0681034
Transportation	86	5.427	1.834	0.0301327	0.1227078

Agriculture

Log GDP per capita	-12.68*** -1.45	-10.48*** -1.33	-9.89*** -1.4	-9.99*** -1.4	-1.44*** -0.28	-0.64 -0.89
Log GDP per capita Sq	0.25*** -0.03	0.20*** -0.03	0.19*** -0.03	0.19*** -0.03		
Log Population	1.73 -2.17	5.51*** -2.02	6.21*** -2.21	5.93*** -2.2	0.04 -1.83	5.42*** -2.08
0-14 Share	-5.98 -8.39	-6.91 -7.12	-7.6 -7.75	-7.13 -7.75	-3.61 -7.24	-79.21** -42.82
65- 75 Share	-7.71 -34.09	-26.27 -34.5	-31.52 -33.88	-42.95* -32.49		
75+ Share	87.23* -55.51	85.83* -53.21	114.26** -51.67	114.42** -51.69		
65+ Share					59.48*** -23.04	-192.89** -111.25
OPEN	1.67*** -0.63	-0.80* -0.63	0.09 -0.63	0.12 -0.63	-1.35** -0.66	-0.68 -0.66
Share AMF	4.42*** -1.84	6.72*** -1.59	6.91*** -1.64	6.76*** -1.64	10.09*** -1.63	7.77*** -1.65
Gini	0.03 -0.03					
65+ Share * 65+ Activity Rate			-0.52 -0.44			
Log GDP per capita * 0-14 Share						-4.14** -1.89
Log GDP per capita * 65+ Share						8.29** -4.55
Constant	153.09*** -26.97	98.70*** -24.47	81.00*** -26.58	83.98*** -26.47	37.26** -19.95	-17.53 -27.13
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
N	507	694	523	523	694	694
R^2 Within	0.62	0.49	0.58	0.58	0.43	0.46
R^2 Between	0.58	0.27	0.18	0.2	0.63	0.25
R^2 Overall	0.6	0.3	0.18	0.2	0.58	0.28
Hausman Test	0	0	0	0	0	0

Mining, Manufacturing and Utilities

Log GDP per capita	9.26*** -1.91	6.56*** -1.7	6.00*** -1.89	6.13*** -1.89	-0.11 -0.35	-0.79 -1.1
Log GDP per capita Sq	-0.20*** -0.04	-0.15*** -0.04	-0.14*** -0.04	-0.14*** -0.04		
Log Population	6.78*** -2.85	-1.34 -2.58	5.80** -2.98	6.17** -2.97	3.37* -2.27	-3.62* -2.57
0-14 Share	-11.34 -11.02	-16.02** -9.11	-22.51** -10.46	-23.13** -10.45	-25.03*** -8.97	-105.20** -53.01
65- 75 Share	-125.42*** -44.92	-45 -44.18	-84.84** -45.72	-69.69* -43.85		
75+ Share	-51.6 -72.17	-175.86*** -68.02	-98.40* -69.72	-98.62* -69.75		
65+ Share					-126.60*** -28.56	232.92** -137.72
OPEN	-4.37*** -0.84	-2.83*** -0.81	-3.13*** -0.85	-3.16*** -0.85	-2.39*** -0.82	-3.24*** -0.82
Share AMF	-4.53** -2.43	-3.57** -2.04	-0.92 -2.22	-0.73 -2.21	-6.27*** -2.02	-3.36** -2.04
Gini	-0.11*** -0.04					
65+ Share * 65+ Activity Rate			0.68 -0.59			
Log GDP per capita * 0-14 Share						4.57** -2.34
Log GDP per capita * 65+ Share						-12.22** -5.63
Constant	-121.05*** -35.32	-21.43 -31.2	-76.73** -35.85	-80.68** -35.7	19.05 -24.72	82.25*** -33.58
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
N	508	698	524	524	695	695
R^2 Within	0.35	0.2	0.29	0.29	0.16	0.21
R^2 Between	0.08	0.001	0.07	0.08	0.04	0.01
R^2 Overall	0.06	0.002	0.05	0.05	0.02	0.0003
Hausman Test	0	0	0	0	0	0

Construction

Log GDP per capita	4.09*** -0.68	3.78*** -0.63	3.65*** -0.75	3.77*** -0.75	0.85*** -0.13	0.19 -0.42
Log GDP per capita Sq	-0.07*** -0.01	-0.06*** -0.01	-0.06*** -0.02	-0.07*** -0.02		
Log Population	-0.22 -1.01	-0.33 -0.96	-0.48 -1.18	-0.11 -1.18	1.27* -0.85	-0.4 -0.97
0-14 Share	-6.18* -3.9	1.82 -3.4	-0.67 -4.14	-1.28 -4.17	-0.94 -3.35	-45.32*** -20.02
65- 75 Share	-12.02 -15.93	-14.37 -16.49	-34.38** -18.08	-19.63 -17.49		
75+ Share	-30.93 -25.92	-33.29* -25.39	-15.71 -27.57	-15.92 -27.82		
65+ Share					-35.31*** -10.65	5.92 -52.02
OPEN	0.47* -0.3	0.74*** -0.3	0.76** -0.34	0.73** -0.34	0.89*** -0.31	0.66** -0.31
Share AMF	0.12 -0.86	-0.51 -0.76	-0.52 -0.88	-0.33 -0.88	-1.50** -0.75	-0.67 -0.77
Gini	0.03** -0.01					
65+ Share * 65+ Activity Rate			0.67*** -0.23			
Log GDP per capita * 0-14 Share						2.22 -0.88
Log GDP per capita * 65+ Share						-0.87 -2.13
Constant	-42.68*** -12.55	-39.32*** -11.65	-35.96*** -14.17	-39.80*** -14.24	-18.43** -9.22	7.78 -12.69
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
N	507	698	524	524	695	695
R^2 Within	0.32	0.21	0.22	0.2	0.17	0.2
R^2 Between	0.17	0.06	0.07	0.12	0.01	0.06
R^2 Overall	0.17	0.12	0.09	0.11	0.04	0.12
Hausman Test	0	0	0.05	0.01	0	0

Services

Log GDP per capita	-0.64 -1.79	0.17 -1.69	0.25 -1.93	0.09 -1.92	0.69 -0.34	1.24 -1.09
Log GDP per capita Sq	0.02 -0.04	0.01 -0.04	0.01 -0.04	0.01 -0.04		
Log Population	-8.23*** -2.68	-3.90* -2.56	-11.54*** -3.04	-11.99*** -3.03	-4.68** -2.2	-1.4 -2.55
0-14 Share	23.19** -10.35	20.87** -9.03	30.78*** -10.67	31.54*** -10.67	22.37*** -8.69	71.32* -52.49
65- 75 Share	146.30*** -42.22	85.75** -43.79	150.72*** -46.63	132.24*** -44.74		
75+ Share	0.77 -68.71	122.00** -67.42	-0.17 -71.09	0.1 -71.18		
65+ Share					102.44*** -27.67	-45.93 -136.37
OPEN	2.27*** -0.79	2.92*** -0.8	2.27*** -0.87	2.31*** -0.87	2.85*** -0.8	3.26*** -0.81
Share AMF	0.01 -2.28	-2.62* -2.03	-5.47*** -2.26	-5.70*** -2.26	-2.32 -1.96	-3.75** -2.02
Gini	0.05* -0.04					
65+ Share * 65+ Activity Rate			-0.83* -0.6			
Log GDP per capita * 0-14 Share						-2.65 -2.32
Log GDP per capita * 65+ Share						4.8 -5.57
Constant	109.58*** -33.28	62.36** -30.93	131.65*** -36.56	136.47*** -36.43	62.13*** -23.95	27.5 -33.25
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
N	507	698	524	524	695	695
R^2 Within	0.6	0.46	0.56	0.56	0.46	0.46
R^2 Between	0.15	0.4	0.26	0.25	0.37	0.5
R^2 Overall	0.24	0.41	0.19	0.18	0.37	0.5
Hausman Test	0.08	0	0	0	0.01	0

Other Services

Log GDP per capita	-4.68*** -1.52	-3.76*** -1.41	-3.88** -1.7	-3.91** -1.7	1.29*** -0.29	2.25*** -0.91
Log GDP per capita Sq	0.13*** -0.03	0.11*** -0.03	0.11*** -0.04	0.11*** -0.04		
Log Population	-5.19** -2.27	-2.75* -2.13	-8.23*** -2.68	-8.32*** -2.67	-5.79*** -1.86	-0.66 -2.12
0-14 Share	13.05* -8.75	17.64*** -7.53	23.35*** -9.42	23.49*** -9.4	23.99*** -7.37	106.24*** -43.73
65- 75 Share	53.19* -35.71	51.12* -36.53	84.29** -41.17	80.83** -39.42		
75+ Share	44.14 -58.1	120.26** -56.25	38.42 -62.78	38.47 -62.7		
65+ Share					101.78*** -23.47	-120.16 -113.63
OPEN	1.82*** -0.66	1.59*** -0.67	1.43** -0.77	1.43** -0.76	1.26** -0.68	1.91*** -0.67
Share AMF	-0.57 -1.93	-4.08*** -1.69	-5.78*** -2	-5.83*** -1.99	-2.13* -1.66	-4.39*** -1.68
Gini	0.09*** -0.03					
65+ Share * 65+ Activity Rate			-0.16 -0.53			
Log GDP per capita * 0-14 Share						-4.40** -1.93
Log GDP per capita * 65+ Share						7.05* -4.64
Constant	102.47*** -28.14	71.98*** -25.8	123.10*** -32.28	124.00*** -32.1	37.03** -20.31	-19.64 -27.71
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
N	507	698	524	524	695	695
R^2 Within	0.64	0.49	0.58	0.58	0.47	0.5
R^2 Between	0.24	0.49	0.24	0.24	0.3	0.64
R^2 Overall	0.31	0.5	0.21	0.21	0.3	0.63
Hausman Test	1	0.01	0.61	0.07	0.01	0.26

Transportation, Storage and Communication

Log GDP per capita	1.53*** -0.59	2.00*** -0.5	1.51*** -0.62	1.53*** -0.62	-0.16* -0.1	-0.41 -0.33
Log GDP per capita Sq	-0.04*** -0.01	-0.05*** -0.01	-0.04*** -0.01	-0.04*** -0.01		
Log Population	-0.74 -0.89	0.07 -0.76	1.1 -0.98	1.13 -0.97	0.95* -0.67	-0.45 -0.77
0-14 Share	-6.07** -3.42	-7.99*** -2.69	-4.66* -3.44	-4.72* -3.43	-9.82*** -2.64	-31.69** -15.8
65- 75 Share	16.14 -13.96	2.96 -13.06	12.14 -15.04	13.58 -14.4		
75+ Share	-34.02* -22.71	-0.18 -20.11	-11.3 -22.93	-11.32 -22.9		
65+ Share					-8.51 -8.39	53.55* -41.06
OPEN	0.03 -0.26	0.18 -0.24	-0.05 -0.28	-0.05 -0.28	0.3 -0.24	0.12 -0.24
Share AMF	-0.99* -0.75	-0.65 -0.6	-0.5 -0.73	-0.48 -0.73	-1.39*** -0.59	-0.78* -0.61
Gini	0.01 -0.01					
65+ Share * 65+ Activity Rate			0.07 -0.19			
Log GDP per capita * 0-14 Share						1.18* -0.7
Log GDP per capita * 65+ Share						-1.99 -1.68
Constant	1.27 -11	-10.8 -9.22	-15.29* -11.79	-15.66* -11.72	7.09 -7.26	22.33** -10.01
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
N	507	698	524	524	695	695
R^2 Within	0.28	0.26	0.29	0.29	0.23	0.25
R^2 Between	0.25	0.11	0.004	0.004	0.02	0.2
R^2 Overall	0.22	0.1	0.001	0.001	0.004	0.17
Hausman Test	0.96	0.69	0.57	0.45	0.26	0.91

Trade

Log GDP per capita	2.51*** -1.07	1.93** -0.88	2.62*** -1.08	2.48** -1.08	-0.44*** -0.18	-0.61 -0.58
Log GDP per capita Sq	-0.07*** -0.02	-0.05*** -0.02	-0.07*** -0.02	-0.06*** -0.02		
Log Population	-2.30* -1.6	-1.22 -1.33	-4.40*** -1.71	-4.81*** -1.7	0.15 -1.16	-0.29 -1.35
0-14 Share	16.20*** -6.18	11.22*** -4.7	12.09** -5.99	12.77** -6.01	8.20** -4.57	-3.24 -27.77
65- 75 Share	76.95*** -25.21	31.67* -22.82	54.32** -26.17	37.86* -25.21		
75+ Share	-9.38 -41.02	1.91 -35.13	-27.27 -39.9	-27.04 -40.1		
65+ Share					9.15 -14.54	20.66 -72.15
OPEN	0.41 -0.47	1.15*** -0.42	0.89** -0.49	0.92** -0.49	1.29*** -0.42	1.23*** -0.43
Share AMF	1.58 -1.36	2.11* -1.06	0.82 -1.27	0.61 -1.27	1.21 -1.03	1.43* -1.07
Gini	-0.04** -0.02					
65+ Share * 65+ Activity Rate			-0.74** -0.34			
Log GDP per capita * 0-14 Share						0.57 -1.23
Log GDP per capita * 65+ Share						-0.26 -2.95
Constant	5.83 -19.87	1.18 -16.12	23.84 -20.52	28.13* -20.53	18.00* -12.59	24.80* -17.59
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
N	507	698	524	524	695	695
R^2 Within	0.13	0.1	0.1	0.09	0.08	0.08
R^2 Between	0.01	0.04	0.08	0.08	0.001	0.01
R^2 Overall	0.03	0.05	0.04	0.04	0.0004	0.01
Hausman Test	0	0.4	0.02	0.05	0.99	0.73

Table 4 Estimates of Coefficients of Age Group Shares on Sector Shares			
SIC	**Sector**	**0-14 Share**	**65+ Share**
0-1	Agriculture	0.0361	0.5948***
2-4	MMU	-0.2503***	-1.26**
	Construction	-0.0094	-0.3531***
5-8	Services	0.2237***	1.0844***
	Other Services	0.2399***	1.0178***
	Transportation and Communication	-0.09982***	-0.0881
	Trade	0.082**	0.0915
311	Food Products	-0.0728**	-0.1254**
313	Beverages	-0.0188*	-0.0085
314	Tobacco	-0.0015	0.037
321	Textile	-0.066***	-0.1219***
322	Wearing Apparel Except Footwear	-0.0581***	-0.0751*
323	Leather Products	-0.01***	0.0021
324	Footwear Except Rubber or Plastic	-0.0145***	0.0103
331	Wood Products Except Furniture	-0.0062	-0.0307*
332	Furniture Except Metal	-0.0068**	-0.0042
341	Paper and Products	-0.0303	-0.019
342	Printing and Publishing	-0.0287***	-0.0206*
351	Industrial Chemicals	-0.0797***	-0.2851***
352	Other Chemicals	-0.0592***	-0.2979***
353	Petroleum Refineries	-0.0036	0.2184**
354	Misc. Petroleum and Coal Products	0.008**	0.039***
355	Rubber Products	-0.0106**	0.0006
356	Plastic Products	-0.0192**	-0.074***
361	Pottery China Earthware	-0.017	-0.0115
362	Glass and Products	-0.0122**	-0.0164***
369	Other Non-Metallic Products	-0.0121*	-0.0023
371	Iron and Steel	-0.0434***	-0.1196***
372	Non-Ferrous Metals	-0.0324**	-0.0254
381	Fabricated Metal Products	-0.0331**	-0.0198
382	Machinery Except Electrical	-0.1525***	-0.3037***
383	Machinery Electric	-0.1509***	-0.4289***
384	Transport Equipment	-0.0929***	-0.1112**
385	Professional and Scientific Equipment	-0.01	-0.0768***
390	Other Manufactured Products	-0.0172***	-0.0469***
300	Total Manufacturing	-0.2302	1.3115**
50-52		0.63**	0.4**
55		-0.8**	-0.15
60-63		0.21**	0.2*
64		-0.06**	-0.04
65-67		-0.12	-0.27**
70-74		0.39*	0.7**
75		-0.04	0.07
80		-0.08*	-0.01
85		-0.002	0.18**
90-93		0.12**	0.08**
95		-0.017**	0.025**

Note: Results for Sectors 50-52 through 95 are based on cross-state data for the U.S. *, **, and ** after the coefficient indicate significance at the 10, 5 and 1 percent levels, respectively

Table 5 Estimated Coefficients of Population Age Share Variables: U.S. Data

Sector	0-14 Share	65+ Share
Agriculture	0.09*	0.41**
Mining	1.08**	-0.34
Manufacturing	-0.17	-0.76***
Construction	-0.08*	-0.10**
EGW	0.02	-0.01
Communication	-0.08**	-0.13**
Transportation	0.13**	0.15**
Education	0.02**	0.045***
Wholesale Trade	-0.06**	-0.06**
Retail Trade	-0.15***	0.105**
Depository Institutions	0.07**	0.48***
Non Depository Institutions	0.01**	0.02**
Insurance	0.03	0.15***
Real Estate	-0.1*	0.07
Business Services	-0.03	-0.25***
Legal Services	-0.02*	0.10***
Health Services	-0.09**	0.13***
Personal Services	-0.035*	0.02
Private Households	0.04***	0.01*
Social Services	-0.01**	0.03**
Hotels, Lodging	-0.02	0.2***
Government	-0.51***	-0.32**

Table 6 Age Group Shares in Total Population 2005-2050 by Region and High and Low Variant Population Growth Projections

Region	Age Group	Share in Total Population 2005	Share in Total Population 2050 High Population Growth Variant	Share in Total Population 2050 Low Population Growth Variant
Developed Countries	0-14	17.0	20.3	11.0
	65+	15.3	22.3	30.3
Less Developed Countries	0-14	30.8	25.5	16.0
	65+	5.5	12.4	17.3
Least Developed Countries	0-14	41.8	33.6	24.8
	65+	3.2	5.7	7.6
United States	0-14	20.7	21.9	12.4
	65+	12.3	17.7	24.2

Source: United Nations, Economic and Social Affairs World Population Prospects 2004 Revision Volume 1 Comprehensive Tables

Table 7 Projections of Sectoral Changes for Different Regions and Population Growth Rate Projections 2000-2050

A. Developed Countries:

Sector	High Variant 0-14 Share	High Variant 65+ Share	Low Variant 0-14 Share	Low Variant 65+ Share
Agriculture	0.119	4.164	-0.2166	8.922
MMU	-0.826	-8.82	1.5018	-18.9
Construction	-0.03102	-2.4717	0.0564	-5.2965
Services	0.73821	7.5908	-1.3422	16.266
Other Services	0.79167	7.1246	-1.4394	15.267
Transportation and Communication	0.329406	-0.6167	-0.59892	-1.3215
Trade	0.2706	0.6405	-0.492	1.3725
Manufacturing	-0.75966	-9.1805	-1.3812	-19.6725
50-52	2.079	2.8	-3.78	6
55	-2.64	-1.05	4.8	-2.25
60-63	0.693	1.4	-1.26	3
64	-0.198	-0.28	0.36	-0.6
65-67	-0.396	-1.89	0.72	-4.05
70-74	1.287	4.9	-2.34	10.5
75	-0.132	0.49	0.24	1.05
80	-0.264	-0.07	0.48	-0.15
85	-0.0066	1.26	0.012	2.7
90-93	0.396	0.56	-0.72	1.2
95	-0.0561	0.175	0.102	0.375

B. Less Developed Countries:

Sector	High Variant 0-14 Share	High Variant 65+ Share	Low Variant 0-14 Share	Low Variant 65+ Share
Agriculture	-0.19133	4.10412	-0.53428	7.01864
MMU	1.32659	-8.694	3.70444	-14.868
Construction	0.04982	-2.43639	0.13912	-4.16658
Services	-1.18561	7.48236	-3.31076	12.79592
Other Services	-1.27147	7.02282	-3.55052	12.01004
Transportation and Communication	-0.529046	-0.60789	-1.477336	-1.03958
Trade	-0.4346	0.63135	-1.2136	1.0797
Manufacturing	-1.22006	-9.04935	-3.40696	-15.4757
50-52	-3.339	2.76	-9.324	4.72
55	4.24	-1.035	11.84	-1.77
60-63	-1.113	1.38	-3.108	2.36
64	0.318	-0.276	0.888	-0.472
65-67	0.636	-1.863	1.776	-3.186
70-74	-2.067	4.83	-5.772	8.26
75	0.212	0.483	0.592	0.826
80	0.424	-0.069	1.184	-0.118
85	0.0106	1.242	0.0296	2.124
90-93	-0.636	0.552	-1.776	0.944
95	0.0901	0.1725	0.2516	0.295

C. Least Developed Countries:

Sector	High Variant 0-14 Share	High Variant 65+ Share	Low Variant 0-14 Share	Low Variant 65+ Share
Agriculture	-0.29602	1.487	-0.6137	2.61712

MMU	2.05246	-3.15	4.2551	-5.544
Construction	0.07708	-0.88275	0.1598	-1.55364
Services	-1.83434	2.711	-3.8029	4.77136
Other Services	-1.96718	2.5445	-4.0783	4.47832
Transportation and Communication	-0.818524	-0.22025	-1.69694	-0.38764
Trade	-0.6724	0.22875	-1.394	0.4026
Manufacturing	-1.88764	-3.27875	-3.9134	-5.7706
50-52	-5.166	1	-10.71	1.76
55	6.56	-0.375	13.6	-0.66
60-63	-1.722	0.5	-3.57	0.88
64	0.492	-0.1	1.02	-0.176
65-67	0.984	-0.675	2.04	-1.188
70-74	-3.198	1.75	-6.63	3.08
75	0.328	0.175	0.68	0.308
80	0.656	-0.025	1.36	-0.044
85	0.0164	0.45	0.034	0.792
90-93	-0.984	0.2	-2.04	0.352
95	0.1394	0.0625	0.289	0.11

D. United States	**High Variant**		**Low Variant**	
Sector	**0-14 Share**	**65+ Share**	**0-14 Share**	**65+ Share**
Agriculture	0.108	2.214	-0.747	4.879
Mining	1.296	-1.836	-8.964	-4.046
Manufacturing	-0.204	-4.104	1.411	-9.044
Construction	-0.096	-0.54	0.664	-1.190
EGW	0.024	-0.054	-0.166	-0.119
Communication	0.096	-0.702	-0.664	-1.547
Transportation	0.156	0.81	-1.079	1.785
Education	0.024	0.243	-0.166	0.536
Wholesale Trade	-0.072	-0.324	0.498	-0.714
Retail	-0.18	0.567	1.245	1.249
Deposit	0.084	2.592	-0.581	5.712
Non Dep.	0.012	0.108	-0.083	0.238
Insurance	0.036	0.81	-0.249	1.785
Real Estate	-0.12	0.378	0.83	0.833
Business	-0.036	-1.35	0.249	-2.975
Legal	0	0.54	0	1.190
Health Services	-0.108	1.62	0.747	3.570
Personal	0.042	0.162	-0.2905	0.357
Private Households	0.048	0.054	-0.332	0.119
Social Services	-0.012	0.162	0.083	0.357
Hotels, Lodging	-0.024	1.08	0.166	2.38
Government	-0.612	-1.728	4.233	-3.808

Source: The entries in parts A-C are computed by multiplying the coefficients of the age group share variables in Table 4 with the region-specific changes in the age group shares from Table 6. Those in part D are obtained by multiplying the coefficients of the age group share variables for the U.S. in Table 5 with the projected changes in age group shares for the U.S. in Table 6. For ISIC Sector definitions for Parts A-C see Tables 2 and 4.