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Aging and Structural Change

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Aging and Structural Change

Ulrich Thießen [1]

Abstract

Many studies analyzed in depth how aging affects aggregate economic performance. But analyses of these effects on the employment structure are scarce and they do not consider that consumption patterns, the supply of goods and services, and also sectoral labor productivity are all likely to adjust to aging and will change. Hence, regression analysis of sectoral employment shares is proposed that controls for aging. For a large panel of countries and a long time period it is found that aging indeed affects relative employment of most sectors statistically highly significant either positive or negative. We also conclude that aging tends to accelerate ongoing structural change. This enables to derive specific policy implications. The approach could thus become a new method in forecasting employment and other effects of aging.

JEL classification: J11, O57, C33

Keywords: Aging, Structural Change, Panel Regressions.

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[1] German Institute for Economic Research, Berlin (uthiessen@diw.de). The author is indebted to Jan-Oliver Menz, Boriss Siliverstovs, Ulrich Fritsche and Paul R. Gregory for valuable discussions without implicating them. Errors are the sole responsibility of the author.

I. Introduction

Many studies analyzed how aging affects aggregate economic performance (e.g. Börsch-Supan 2001, Börsch-Supan et al. 2003, 2005, 2006, Bös and von Weizsäcker 1988, Denton 1988, Oliveira et al. 2005, McMorrow and Roeger 1999 and 2003). There have also been attempts to analyze the effects of aging on both the structure of GDP and private demand for goods and services (e.g. Buslei et al. 2007, Börsch-Supan 2003a, 2003b, Lührmann 2005, Oliveira et al. 2005, Serow and Sly 1988): These studies use the age specific private consumption patterns and combine them with demographic forecasts. To derive employment effects of aging, the forecasted consumption changes may be multiplied with sectoral labor productivity (Börsch-Supan 2003b). But this approach has several limitations. Firstly, since private consumption is analyzed, a substantial part of the economy is omitted. Secondly, the approach does not consider potential changes in the consumption patterns of the different age groups, which may result from responses of the supply of goods and services to aging and from demand changes. Thirdly, sectoral labor productivity may also change and the available sectoral labor productivity figures may not correspond adequately to the groups of consumption goods and services.

Another approach of analyzing effects of aging on an economy’s structure is regression analysis of sectoral employment shares that adequately controls for aging. Surprisingly, and to the best of our knowledge, this analysis has not yet been performed. Since the process of aging intensified considerably during the past decades in many countries, regression analysis captures the effects of aging: all economic adjustments to aging, be it in the behaviour of consumption patterns, in the supply of goods and services or in productivity, are taken into account. And the analysis may cover the whole economy.

The period used for our regressions covers the past three decades when aging accelerated in many countries. For a large panel of countries and for this long time period we find that aging indeed affects relative employment of most sectors statistically highly significant and either positive or negative. The process of structural change, that takes place also in the absence of aging, appears to be promoted. The paper is structured as follows: Section 2 provides a brief overview of ‘aging’ and asks whether there are current and future characteristics of demographic developments that are unique in economic history. Section 3 elaborates briefly on the salient features and trends of structural change in our large panel data set. Section 4 provides our empirical analysis of the effects of aging on structural change. First we present our estimates and then compare them with findings of the literature. Section 5 concludes.

II. A brief look at the aging process: what is different in the coming decades from the past 150 years?

It needs to be emphasized and acknowledged that the commonly defined “dependency ratio”, i.e. the relation of persons not involved in the working and income generating process relative to those that are involved, has been rising in most industrial countries not only since recent decades but that this is a very long run development. In many industrial countries this rise has a history of several hundred years. There is, however, a difficulty to show this clearcut in a graph using the commonly defined so-called dependency ratios, i.e. the ratios of young and/or old persons to those of middle age because age is used as the only criteria defining the populations groups and not actual occupation. But in former times, a larger share of the persons below 20 years of age, were working, i.e. had a gainful occupation, than today. In addition, in many countries the share of young people enrolled in higher education has a long term rising trend and the average age, at which gainful employment starts, has been increasing. Also there may be persons in the age group of the commonly defined labor force (people of 20-65 years) that are in fact not participating. Finally, detailed population statistics are starting only in the second half of the 19th century. Overall then, the steepness of the long run declining trend of the young-age dependency ratio in many industrial countries tends to be biased downwards. This also means that the rising long run trend of the total dependency ratio may be somewhat underestimated. At least for the first decades of population statistics in the 19th and 20th century, the dependency ratios have to be interpreted as carefully as is true with regard to population forecasts.[2]

Figure 1 shows for Germany -as an example for industrial countries and beginning in 1871- three dependency ratios and the ratios of the old and young to the population. Since particularly the figures for the earliest available years are the most unreliable with regard to economic dependency of particular age groups, one can argue that there is a long run trend increase in the total dependency ratio.

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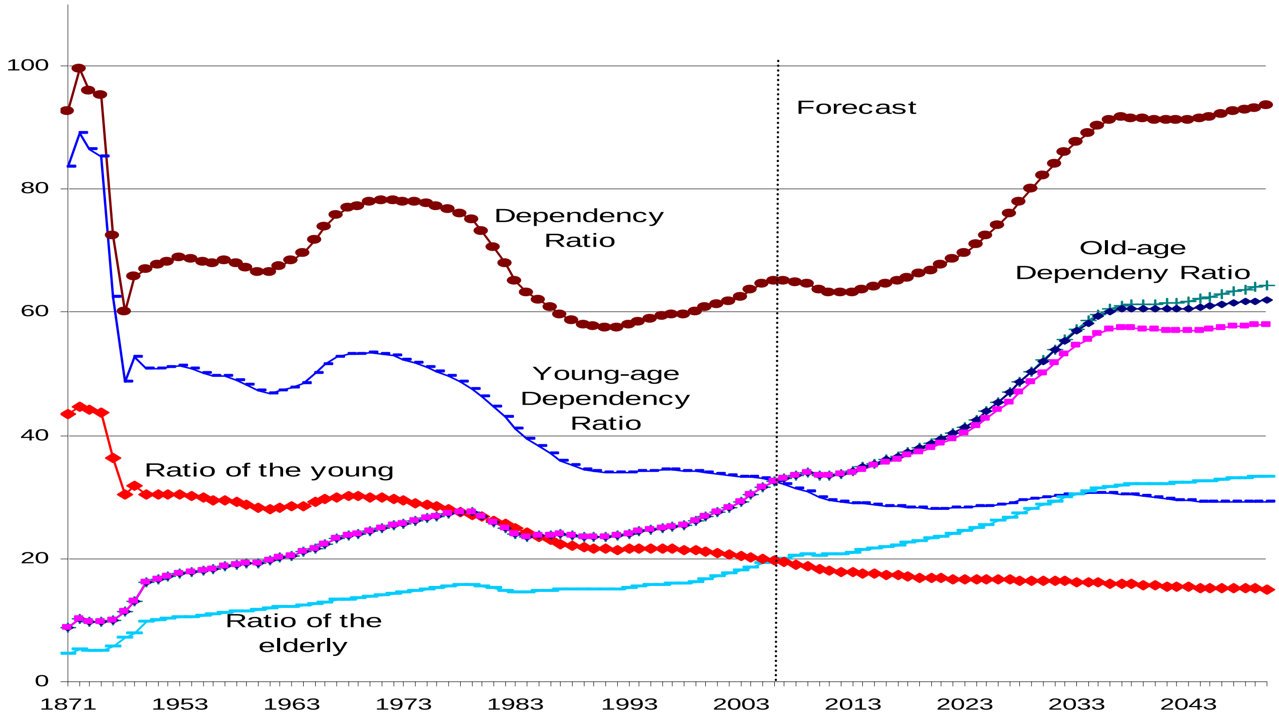
[2] Population forecasts should be treated carefully because they can only extrapolate the current state. Neither wars, nor deep changes in fertility ratios (such as the so-called German Baby-Boom) nor technical progress (for instance the invention of the anti baby pill) are predictable.

Figure 1: Population structure in Germany 1871 - 2050



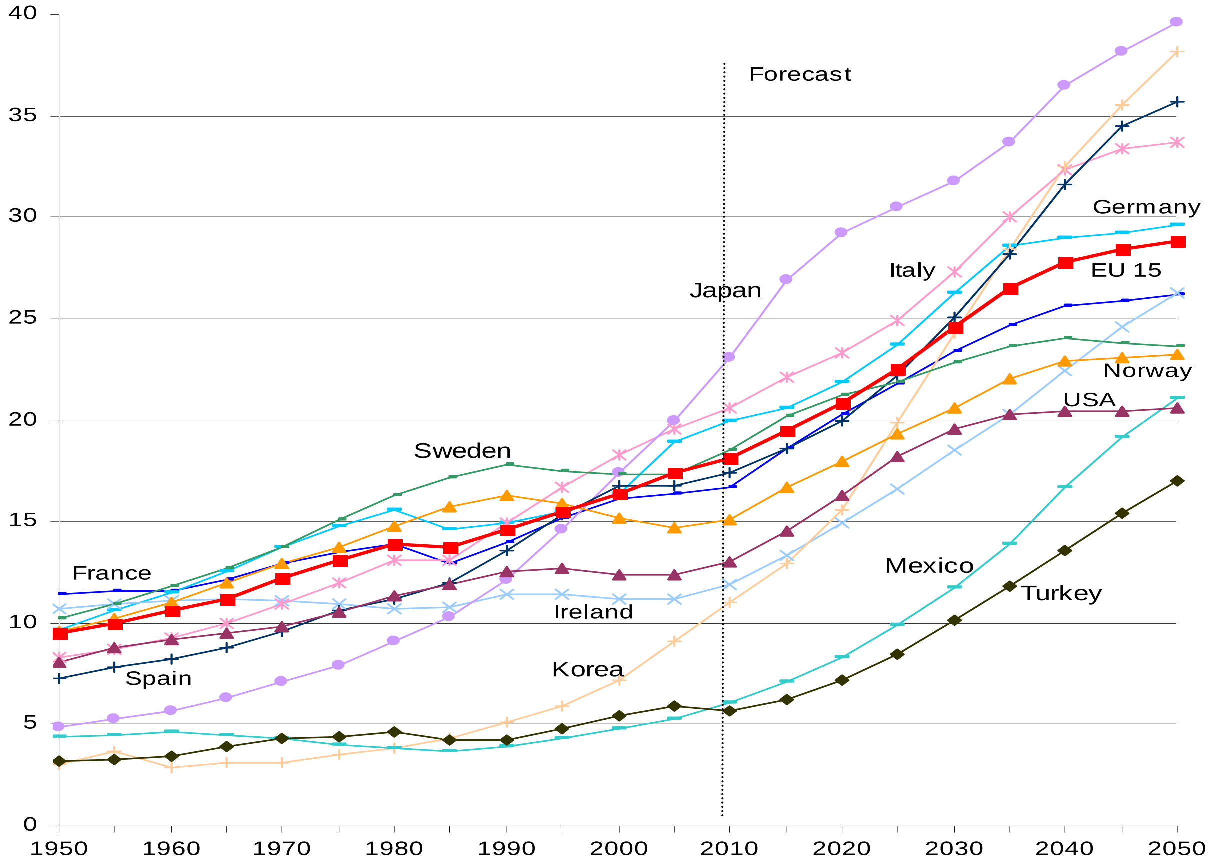
Note: The dependency ratios in this figure use the potential labor force, i.e. people between 20 and 65, as denominator, whereas the two other indicators use total population. For the Old-age dependency ratio, three forecast scenarios are shown. The forecasts start in 2005.
Source: German Federal Institute for Population Research, German Federal Statistical Office.

There is also a long-lasting demographic trend that started at the beginning of the 20th century and that will accelerate in the coming decades: This is an increase in the ratio of the elderly, either relative to total population or to the labor force, i.e. people between 20 and 65 years of age.

This trend occurred in both industrial and developing countries. The important point is that this development appears to have accelerated during relatively recent times and that this acceleration may continue in many industrial countries, according to current projections, until about 2030-2040.

Figure 2 shows this for the average of EU 15 countries and several other OECD countries. We note that Japan experienced already since two decades the steepest increase in the ratio of people above 65 years of age to total population among all OECD countries. By contrast, especially the Scandinavian countries such as Sweden and Norway will stay below the predicted average of the EU 15.

Figure 2: Ratio of population aged 65 and above to total population for selected OECD countries 1950 - 2050



Source: OECD Factbook 2007: Economic, Environmental and Social Statistics, Paris.

Figure 2 also makes clear, that the aging process of modern societies is a long-lasting trend, even if it will intensify in the forthcoming years. This observation led to the idea presented in this paper, that future structural economic change may be forecast by using the calculated impact of aging in the past. In our empirical analysis we use as proxies for aging both the ratio of elderly to population and the old age dependency ratio since there is no prior reason to prefer one of these two indicators of aging.

III. Salient features of structural change in our panel data set

Our data set includes a maximum of 54 selected developing and developed economies.[3] We use ILO employment data for nine sectors and all other data were drawn from the World Development Indicators data base of the World Bank. The longest time period covered was 1970-2004. Since this paper concentrates on analyzing effects of aging on the employment structure, we use sectoral employment shares as the dependent variable in our regressions. These shares are shown in figures 1a-1g together with per capita income, measured in constant purchasing power parity. The figures show clear long run trends of structural change: The agricultural employment share is continuously declining with rising per capita income (figure 1a). Relative employment in the four sectors ‘manufacturing’, ‘construction’, ‘wholesale and retail trade, restaurants and hotels’ and ‘transport, storage, and communication’ is first rising and then declining (figures 1b-1e). And there are two large services sectors whose employment shares are continuously rising with increasing per capita income, namely ‘financial and related services’ (figure 1f) and ‘community, social, and personal services’ (figure 1g)[4]. Hence, these data allow us to define ‘normal’ long run structural change as decreases of relative employment in the seven sectors:

- agriculture,
- mining and quarrying,
- manufacturing,
- electricity, gas and water,
- construction,
- wholesale, retail trade, restaurants and hotels, and
- transport, storage, communication.

And ‘normality’ means relative employment growth in the remaining two services sectors:

- financial services, real estate and related services and
- community, social, and personal services.

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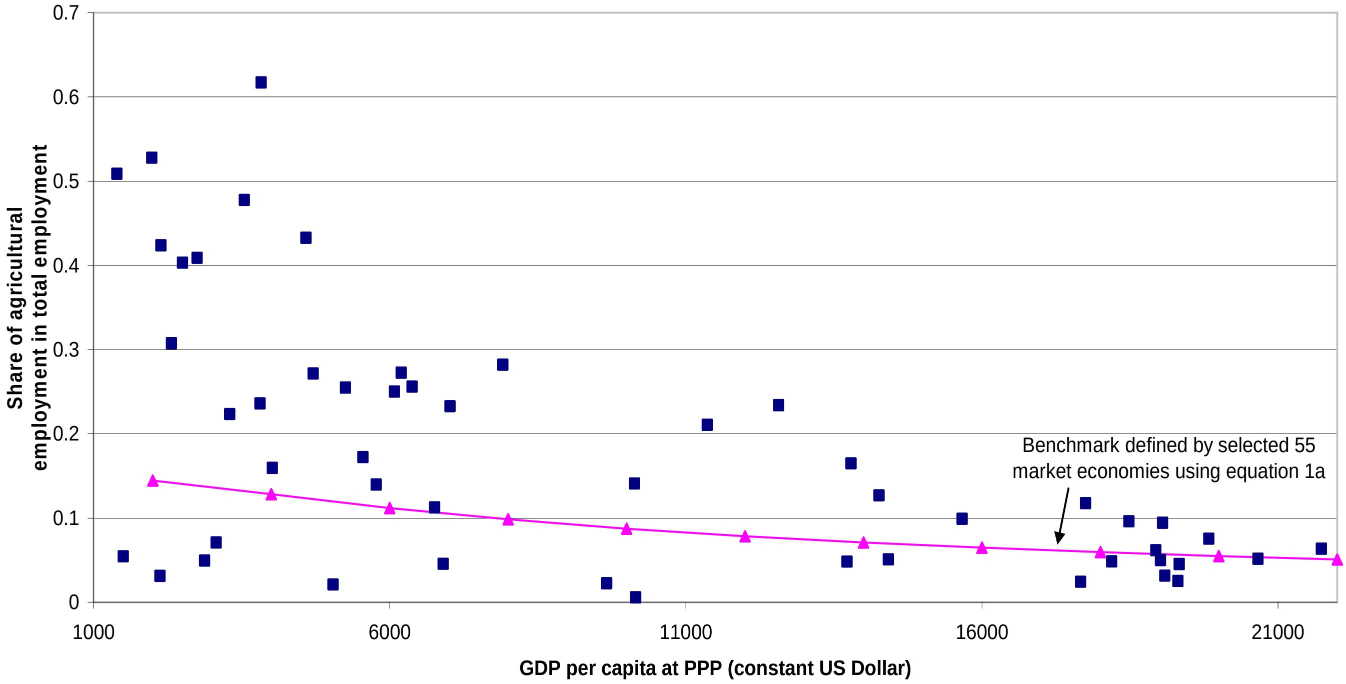
[3] Only market economies were included that do not have unusual characteristics, such as, for instance, a very small population (less than one million) or an extremely large share of GDP derived from extraction of natural resources. The chosen countries were: Argentina, Australia, Austria, Belgium, Bolivia, Brazil, Canada, Chile, Colombia, Costa Rica, Cyprus, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Finland, France, Germany, Greece, Honduras, India, Indonesia, Ireland, Israel, Italy, Jamaica, Japan, Korea, Malaysia, Mauritius, Mexico, Morocco, Netherlands, New Zealand, Nicaragua, Norway, Pakistan, Panama, Peru, Philippines, Portugal, South Africa, Spain, Sri Lanka, Sweden, Switzerland, Thailand, Trinidad and Tobago, Turkey, United Kingdom, USA, Uruguay, and Venezuela.

[4] The latter sector includes government.

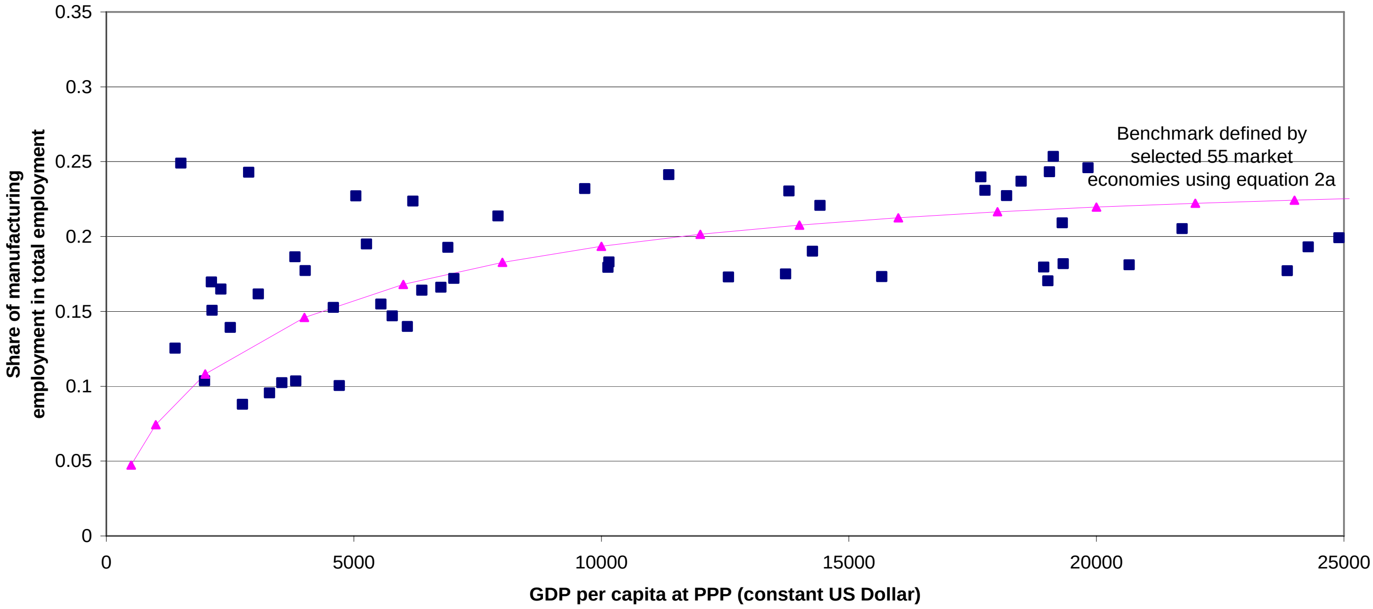
Figure 1a
Sectoral Employment Share of Agriculture in 55 Market Economies
(long run averages 1/)



Benchmark defined by selected 55 market economies using equation 1a

1/ The averages cover for most countries the period 1985-2004. For several countries this period is shorter due to data availability but it includes at least 10 years.
Source: Own calculations.

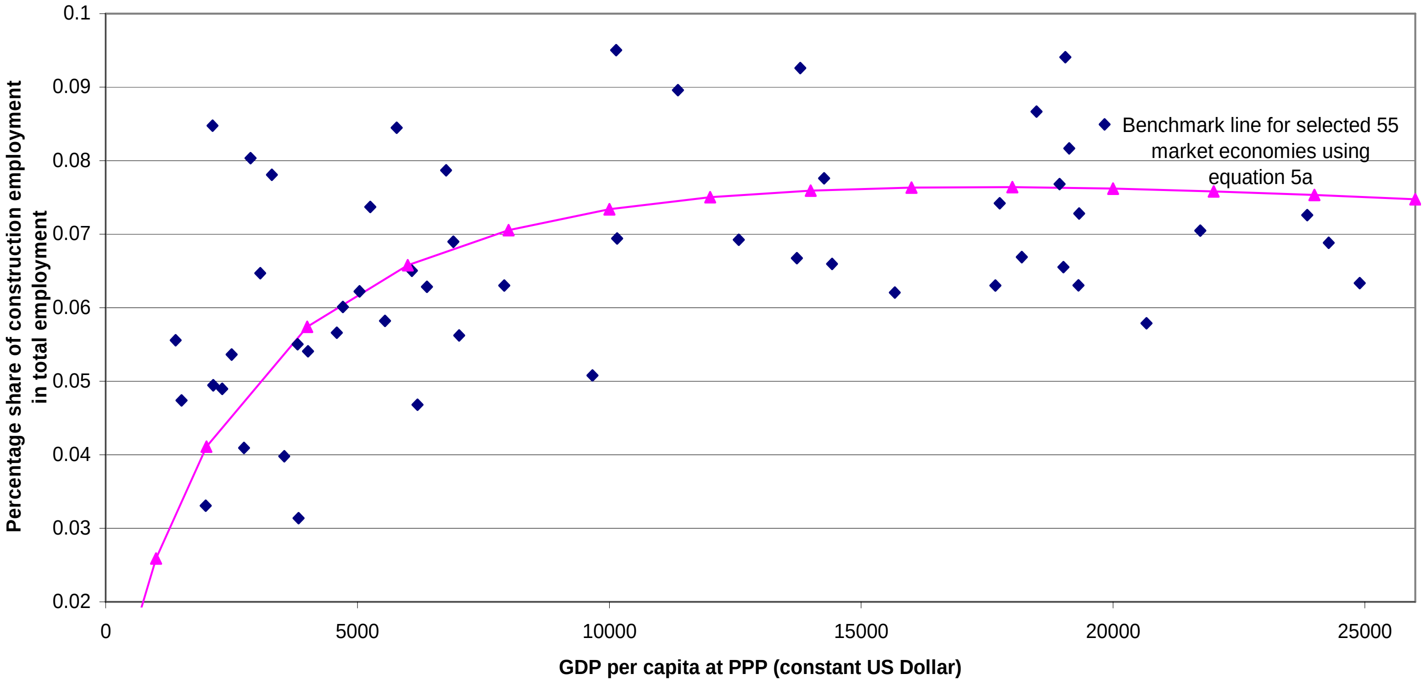
Figure 1b
Sectoral Employment Share of Manufacturing in 55 Market Economies
(long run averages 1/)



Benchmark defined by selected 55 market economies using equation 2a

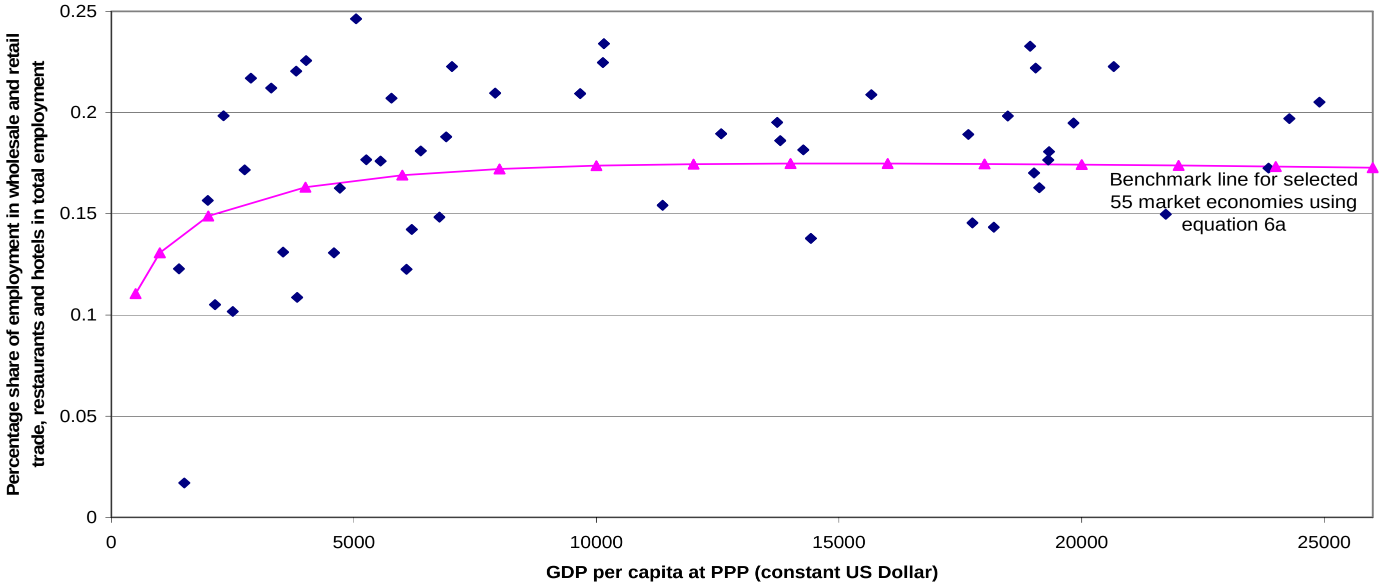
1/ The averages cover for most countries the period 1985-2004. For several countries this period is shorter due to data availability but it includes at least 10 years.
Source: Own calculations.

Figure 1c
Sectoral Employment Share of Construction in 55 Market Economies
(long run averages 1/)



1/ The averages cover for most countries the period 1985-2004. For several countries this period is shorter due to data availability but it includes at least 10 years.
Source: Own calculations.

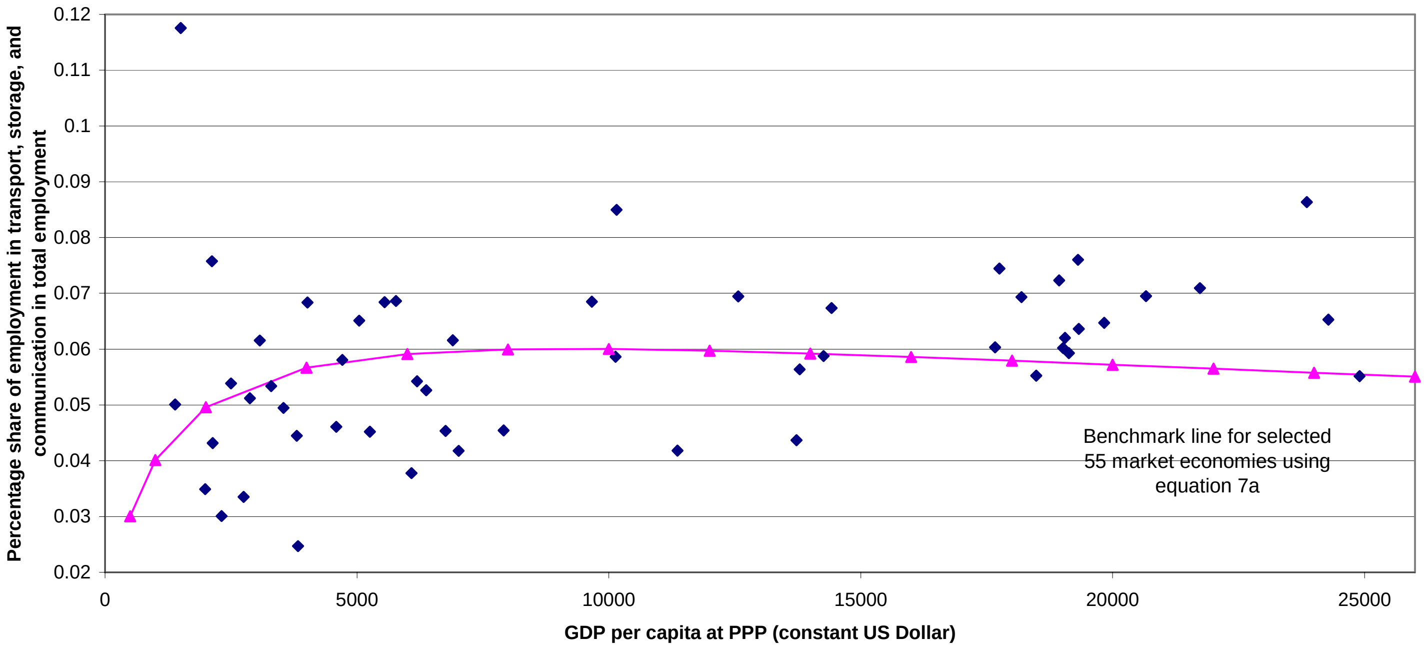
Figure 1d
Sectoral Employment Share of Wholesale and Retail Trade, Restaurants and Hotels in 55 Market Economies
(long run averages 1/)



1/ The averages cover for most countries the period 1985-2004. For several countries this period is shorter due to data availability but it includes at least 10 years.
Source: Own calculations.

Figure 1e

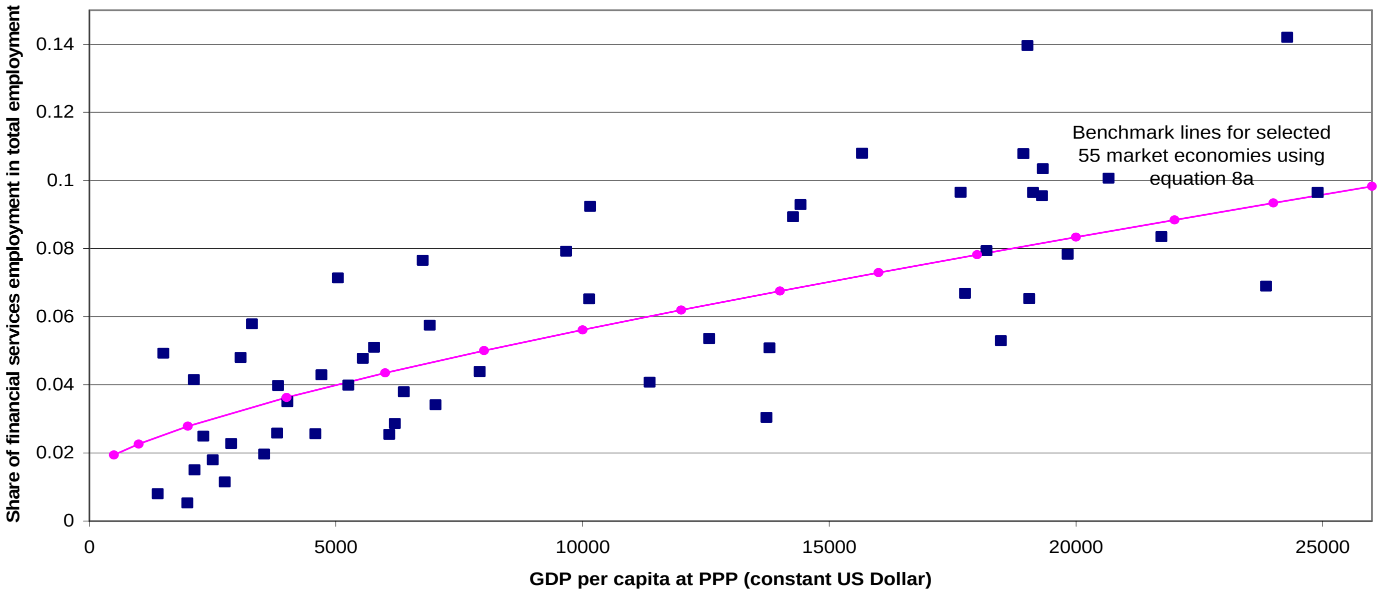
Sectoral Employment Share of Transport, Storage, and Communication in 55 Market Economies (long run averages 1/)



1/ The averages cover for most countries the period 1985-2004. For several countries this period is shorter due to data availability but it includes at least 10 years.
Source: Own calculations.

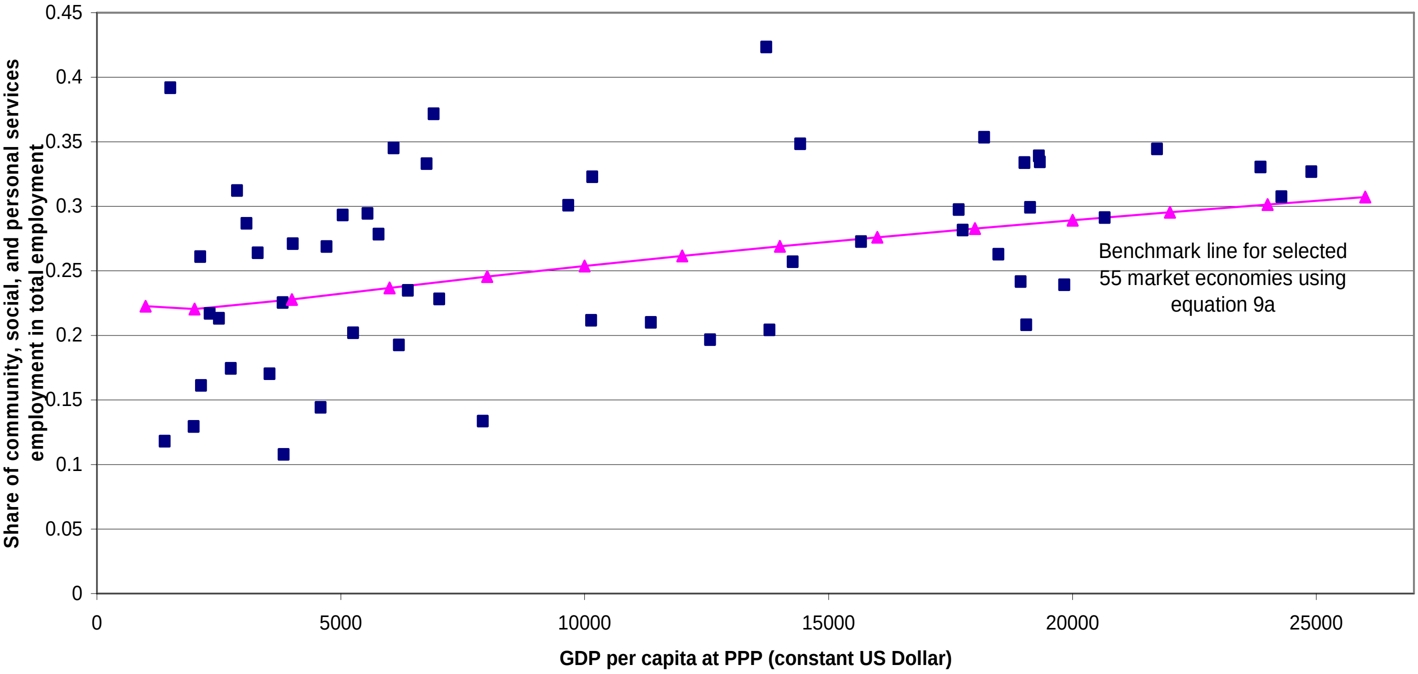
Figure 1f

Sectoral Employment Share of Financial and Related Services in 55 Market Economies (long run averages 1/)



1/ The averages cover for most countries the period 1985-2004. For several countries this period is shorter due to data availability but it includes at least 10 years.
Source: Own calculations.

Figure 1g
Sectoral Employment Share of Community, Social, and Personal Services in
55 Market Economies
(long run averages 1/)



1/ The averages cover for most countries the period 1985-2004. For several countries this period is shorter due to data availability but it includes at least 10 years.
Source: Own calculations.

IV. Empirical estimates of the effects of aging on structural change

a. Panel regressions

We use panel regressions for our sample of up to 55 selected developing and developed economies to explain their sectoral employment shares. We report the results of the total of nine sectors. The explanatory variables included per capita income (Ypc), measured in purchasing power parities, and its square to account for non-linear relationships, the size of the economies proxied by population (POP), and the endowment of natural resources (NR).[5] We also include proxies for “openness” (Trade), i.e. the sum of exports and imports as a ratio to GDP, human capital (HC), namely school and higher education enrollment ratios, to measure potential effects of education, several variables to capture the effect of government policies (GP), namely the government consumption expenditure share[6], tax revenues to GDP, taxes on international trade to GDP, and military expenditure shares. A dummy variable (D) is included to account for the 1997/98 Asian financial crisis in five countries (Indonesia, Korea, Malaysia, Philippines and Thailand).[7] However, our variable of primary interest is aging (A), represented by the two proxies already described, namely the ratio of elderly either to the total population or to the labor force.[8]

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[5] These variables were first introduced with the methodology of analyzing structural change pioneered by Chenery and his associates, see Chenery 1960, Chenery and Taylor 1968, Chenery and Syrquin, 1975. In the context of the analysis of structural change in transition economies the methodology was becoming popular again, see, for instance, Döhrn and Heilemann (1996), and Raiser et al. (2004). We proxied agricultural resources by permenant cropland per capita. Other natural resources were proxied by a resource depletion index, defined as depletion of energy and minerals, and net forest depletion, in percent of gross national income, where each type of depletion was given equal weight. A third proxy for all natural resources was also considered, namely the share of primary exports (agricultural raw materials, ores, basic metals, and fuels) in exports of goods and services.

All variables were transformed into natural logarithms except the dummy and the proxies for natural resources. The regressions include a constant for each country and a time dummy for each year (cross-section and period fixed effects model).[9] Thus, the basic model is:

$$
\begin{aligned}
\ln (LF^{i}_{jt}/LF_{jt}) = \; & a^{i}_{0} + \underset{(+/-/?)}{a^{i}_{1} \ln Ypc_{jt}} + \underset{(-/+/?)}{a^{i}_{2} (\ln Ypc)^{2}_{jt}} + \underset{(+/-/?)}{a^{i}_{3} \ln Trade_{jt}} + \underset{(+/?)}{a^{i}_{4} \ln POP_{jt}} + \underset{(+/?)}{a^{i}_{5} \ln NR_{jt}} \\
& + \underset{(+/?)}{a^{i}_{6} \ln HC_{jt}} + \underset{(?)}{a^{i}_{7} \ln GP_{jt}} + \underset{(?)}{a^{i}_{8} D_{Asia5,\,97\text{-}98}} + \underset{(?)}{a^{i}_{9} A_{jt}} + u^{i}_{j} + v^{i}_{t} + e^{i}_{jt} \qquad (1)
\end{aligned}
$$

where i represents the sectors, j represents the countries, u_j represents country specific effects, v_t represents period specific effects, and e_{jt} is an error term.

Only for some sectors we expect certain signs of the independent variables. In most cases they are theoretically indeterminate as shown in parenthesis below the independent variables in equation 1, including our aging variable. For instance, with regard to agriculture we expect a declining employment share as per capita income rises and thus a positive sign for coefficient a_1 and a negative sign for coefficient a_2. Since international trade promotes adjustment of the production structure according to comparative advantage, which tends to promote production in the long-run in all trading partner countries, a positive sign of the trade variable would be expected for sectors producing tradeable goods like agriculture and manufacturing. This implies a negative sign for sectors producing non-tradeables. Country size, measured by population, is expected to have a positive effect on relative employment in sectors that produce with economies of scale, for instance, agriculture and manufacturing. Natural resource wealth is expected to affect relative employment in those sectors positively, which use or process these resources. Human capital is expected to positively influence relative employment in sectors producing skill-intensive goods and services such as manufacturing and financial services. No prior expectations exist as to the effects of government policies on the employment structure.

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[6] We emphasize that this variable is simultaneously a proxy for the size of the public sector.

[7] The dummy variable equals one for these two years and these five countries, and zero otherwise.

[8] Since we use mainly data provided by the World Bank, the group of elderly is defined as persons above 64 years o f age. The labor force is defined as persons between 20 and 64 years of age.

[9] Formal tests of each regression strongly argued in favor of the two-way fixed effects model against the model with no fixed effects: the Hausman specification test rejected consistently the random-effects model as a valid specification and the likelihood ratio test rejected consistently the hypothesis of no fixed effects. For reasons of space the estimates for country and year dummies are, however, not reported in table 1.

We use sectoral ILO employment data and all other data were drawn from the ‘World Development Indicators’ data base of the World Bank. The longest time period covered was 1970-2004. For each sector three regressions are reported in Table 1: the first equation does not include an aging variable and the second and third consider the two proxies of aging, respectively. The reported final specifications in table 1 were found through robustness tests so as to include only those variables with estimated consistently stable and statistically significant coefficient signs.[10]

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[10] The robustness tests were performed for each regression by including successively those independent variables discussed in the beginning of this section, which were not considered in the final specifications reported in table 1.

Table 1

Panel Regression Results of Sectoral Employment Share Functions

Equation:	(1a)	(1b)	(1c)	(2a)	(2b)	(2c)	(3a)	(3b)	(3c)
Independent Variables:		Agriculture			Manufacturing			Mining and Quarrying	
Sample period		1975-2004			1975-2004			1975-2004	
Constant	-27.509	-24.962	-28.695	-11.059	-12.198	-11.607	-21.246	-20.203	-23.735
	(-10.761)***	(-8.475)***	(-8.833)***	(-12.531)***	(-14.553)***	(-13.538)***	(-9.535)***	(-9.393)***	(-11.059)***
ln (real per capita GDP)	3.024	3.104	3.0661	1.289	1.026	1.123	4.178	4.434	3.836
	(5.616)***	(5.747)***	(5.712)***	(7.053)***	(5.902)***	(6.305)***	(8.358)***	(9.185)***	(7.999)***
(ln real per capita GDP)^2	-0.194	-0.2004	-0.1994	-0.0643	-0.0518	-0.0561	-0.265	-0.271	-0.238
	(-6.317)***	(-6.447)***	(-6.424)***	(-6.075)***	(-5.163)***	(-5.443)***	(-9.295)***	(-9.857)***	(-8.674)***
ln (Trade)	0.327	0.324	0.309	0.114	0.121	0.127			
	(5.606)***	(5.545)***	(5.321)***	(5.949)***	(6.654)***	(6.827)***			
ln (Population)	0.856	0.821	0.787	0.169	0.262	0.3016			
	(4.841)***	(4.593)***	(4.293)***	(2.844)**	(4.638)***	(5.065)***			
ln (Gov. consumption expenditures/GDP)	0.1439	0.1510	0.1520	-0.102	-0.113	-0.1229			
	(2.544)**	(2.652)***	(2.672)***	(-5.329)***	(-7.148)***	(-6.592)***			
Agricultural resources 1/	0.0108	0.0094	0.0093						
	(3.228)***	(2.660)***	(2.664)***						
Natural resource endowment excluding	0.0034	0.0035	0.004				0.0357	0.0599	0.0634
agricultural resources 2/	(0.469)	(0.496)	(0.542)				(1.637)	(2.826)***	(3.012)***
Natural resource endowment including				-0.449	-0.447	-0.448			
agricultural resources 3/				(-8.382)***	(-8.856)***	(-8.643)***			
ln (Elderly/Total Population) 4/		**-0.18**			**0.485**			**-1.38**	
		(-1.969)**			**(11.551)*****			**(-9.057)*****	
ln (Elderly/Population ages 15-64) 5/			**-0.182**			**0.401**			**-1.38**
			(-1.477)			**(8.434)*****			**(-9.057)*****
adj. R^2	0.93051	0.93102	0.93079	0.8978	0.9091	0.9041	0.881853	0.890214	0.891855
S.E. of regression	0.28044	0.27830	0.27850	0.093688	0.08836	0.09075	0.337645	0.325478	0.323037
Akaike info criterion	0.3698	0.35406	0.35664	-1.823763	-1.940065	-1.886682	0.738193	0.665595	0.650537
F-Statistic of the joint significance of all regressors	173.328	171.9443	173.5822	116.1921	130.6577	123.2437	101.8959	109.3348	111.1812
Countries	54	54	54	54	54	54	54	54	54
Observations (unbalanced sample)	1156	1156	1156	1155	1155	1155	1150	1150	1150

Note: Pooled Least Squares method with cross-sections fixed effects (dummies) and period fixed effects (dummies) is used on the assumption that the explanatory variables are exogenous. Both the joint cross-section and the joint period fixed effects were in each regression statistically highly significant. T-statistics in parentheses. * indicates statistical significance of the respective variable at the 10 percent level; ** indicates significance at the 5% percent level; *** indicates significance at the 1% percent level.

1/ Proxy for agricultural resources: permanent cropland per capita.

2/ Resources depletion index: Depletion of energy and minerals, and net forest depletion, in percent of gross national income, and each type of depletion given equal weight. From the World Bank, World Development Indicators.

3/ Share of primary exports (agricultural raw materials, ores, basic metals, fuels) in exports of goods and services.

4/ Natural logarithm of the ratio of elderly (ratio of persons ages 65 and above to the total population).

5/ Natural logarithm of the old age dependency ratio (ratio of persons ages 65 and above to the population ages 15-64).

Source: Author's calculations.

Table 1 concluded
Panel Regression Results of Sectoral Employment Share Functions.

Equation	(7a)	(7b)	(7c)	(8a)	(8b)	(8c)	(9a)	(9b)	(9c)
Independent Variables:		Transport, Storage and Communication			Financial Services, Real Estate and Related Services			Community, Social and Personal Services	
Sample period		1975-2004			1975-2004			1975-2004	
Constant	-9.484	-9.167	-8.982068	5.601	5.0337	5.282	2.135	0.982	2.0645
	(-15.236)***	(-14.017)***	(-13.768)***	(3.116)***	(2.896)***	(3.007)***	(2.051)**	(0.830)	(1.976)**
ln (real per capita GDP)	1.317	1.249	1.2152	1.415	0.716	0.881	0.6818	0.6516	0.6506
	(9.574)***	(8.678)***	(8.492)***	(3.952)***	(2.007)**	(2.452)**	(3.114)***	(2.976)***	(2.931)***
(ln real per capita GDP)^2	-0.065	-0.062	-0.0597	-0.0532	-0.0188	-0.0256	-0.0287	-0.027	-0.0271
	(-8.375)***	(-7.456)***	(-7.289)***	(-2.609)***	(-0.928)	(-1.254)	(-2.285)**	(-2.145)**	(-2.128)**
ln (Trade)							-0.0592	-0.0584	-0.0591
							(-2.817)***	(-2.785)***	(-2.809)***
ln (Population)				-1.034	-0.877	-0.7984	-0.4193	-0.3511	-0.4016
				(-8.293)***	(-7.186)***	(-6.282)***	(-5.873)***	(-4.462)***	(-5.404)***
ln (Gov. consumption expenditures/GDP)	0.050	0.0541	0.0561						
	(2.785)***	(2.98)***	(3.097)***						
ln (Gross fixed capital formation)							-0.165	-0.162	-0.163
							(7.773)***	(7.623)***	(7.586)***
ln (Human resources) 1/				0.0771	0.0882	0.0884	0.0722	0.079	0.0739
				(5.412)***	(6.378)***	(6.302)***	(2.141)**	(2.339)**	(2.187)**
Asia financial crisis dummy 2/	0.132	0.132	0.131				0.067	0.067	0.0667
	(4.041)***	(4.029)***	(4.008)***				(2.223)**	(2.235)**	(2.222)**
ln (Elderly/Total Population) 3/		**fragile sign** 4/			**0.642**			**0.041**	
					(7.961)***			**(2.036)****	
ln (Elderly/Population ages 15-64) 5/			**fragile sign** 4/			**0.571**			**0.045**
						(6.516)***			**(0.855)**
adj. R^2	0.896685	0.89682	0.898179	0.96598	0.968241	0.967517	0.943064	0.943319	0.943042
S.E. of regression	0.0942	0.094139	0.093516	0.151182	0.146072	0.147727	0.075461	0.075292	0.075475
Akaike info criterion	-1.816448	-1.816993	-1.830256	-0.858952	-0.926786	-0.90425	-2.234627	-2.23797	-2.233109
F-Statistic of the joint significance of all regressors	120.9112	119.7219	121.4892	336.4753	356.8099	348.6209	166.424	165.1076	164.264
Countries	55	55	55	54	54	54	55	55	55
Observations (unbalanced sample)	1203	1203	1203	958	958	958	780	780	780

Note: Pooled Least Squares method with cross-sections fixed effects (dummies) and period fixed effects (dummies) is used on the assumption that the explanatory variables are exogenous. Both the joint cross-section and the joint period fixed effects were in each regression statistically highly significant. T-statistics in parentheses. * indicates statistical significance of the respective variable at the 10 percent level; ** indicates significance at the 5% percent level; *** indicates significance at the 1% percent level.
1/ Sum of primary, secondary, and tertiary school enrollment ratios from World Bank Development Indicators.
2/ Dummy variable representing the financial crisis shock during 1997 and 1998 in 5 Asian countries (Indonesia, Korea, Malaysia, Phillipines, Thailand). The variable attains the value one for these two years and these five countries, and zero otherwise.
3/ Natural logarithm of the ratio of elderly (ratio of persons ages 65 and above to the total population).
4/ Sign is highly fragile, i.e. it is switching dependent upon whether or not the variable is transformed into a natural logarithm.
5/ Natural logarithm of the old age dependency ratio (ratio of persons ages 65 and above to the population ages 15-34).
Source: Author's calculations.

As can be seen in table 1 the proxies of aging raise in almost all cases the fit (i.e. they raise the adjusted R^2), improve the overall quality of the regressions and are consistently highly statistically significant. The first proxy of aging, the ratio of elderly to the population, has consistently a somewhat higher significance than the second one, the ratio of elderly to the labor force. For three of the nine sectors, namely ‘electricity, gas and water’, ‘construction’, and ‘transport, storage and communication’, the estimated signs of the aging variables were not robust to variations in the specifications.

It is interesting to note that this fragility of the estimated signs corresponds to conflicting results obtained in studies of the effects of aging on the structure of consumption demand as discussed briefly in the following section. Overall then we find that, ceteris paribus, aging causes shrinking relative employment in:

- agriculture and
- mining and quarrying.

And it causes rising relative employment in:

- manufacturing, and in the services sectors:
- wholesale and retail trade, restaurants and hotels,
- financial and related services and
- community, social, and personal services.

The effect of aging on employment is unclear with regard to the sectors:

- electricity, gas, and water,
- construction, and
- transport, storage, and communication.

b. Comparison with ‘normal’ structural change and with estimates of effects on the structure of private consumption goods and services

Comparing our estimates with ‘normal’ structural change summarized in section 3, we find that only in two cases is aging estimated to affect relative employment in the opposite direction than ‘normal’ structural change: This refers to manufacturing and wholesale and retail trade, restaurants and hotels, which are ‘normally’ shrinking and where aging has a positive impact. Hence, aging may slow down the decline of relative employment in these two sectors. But since it promotes employment growth in the relatively large services sectors financial services –the fastest growing sector- and community, social, and personal services, and given that the three sectors, where the estimated impact of aging is unclear are not very large[11] and have a long run tendency to decline one may conclude that on balance aging is promoting normal ongoing structural change.

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[11] These sectors are electricity, gas, and water, construction, and transport, storage and communication. Together they account on average for about 13 percent of total employment in the group of the 15 OECD countries with highest per capita income.

We may also note that the sectors, where aging promotes relative employment growth, are - with the exception of manufacturing- services sectors. These tend to have relatively low productivity growth. Hence, aging may have an overall somewhat negative effect on long-term average productivity growth.

Finally, table 2 compares our regression results with those of the only currently available other study that estimates employment effects of aging (Börsch-Supan 2003).[12] There are, however, several more studies that estimate effects of aging on consumption demand in industrial countries (OECD 2005, Lührmann 2005, and Buslei et al. 2007). It is interesting to note that these studies and that of Börsch-Supan (2003b) agree in the estimated sign of the effects of aging with regard to most groups of goods and services. The only groups where there are differences among them are energy, education and leisure, and furniture and home electronics.

All these studies consider, however, only effects of aging on private consumption goods and services – extended in Börsch-Supan (2003b) to derive also employment effects in producing these goods and services – and thus they consider only a part of the demand side of the economy. Hence, they cannot be directly compared to our results for the sources side of the whole economy. Nevertheless, in table 2 an attempt was made to assign consumption goods and services, shown on the right side of the table, roughly to the sectors of the sources side of GDP, shown on the left side of the table. On each side of the table the estimated effects of aging are shown. As one can see the results are broadly consistent with each other. There is only one case of conflicting signs, namely in the group of services with regard to education and leisure. But regarding this group of goods and services the mentioned other studies on effects of aging on consumption demand did not agree on the estimated sign.

Overall, our estimated employment effects are consistent with the empirical studies on the effects of aging.

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[12] The methodology used in Börsch-Supan (2003b) is to use today’s age specific private consumption for goods and services and combine it with a population forecast to derive the future demand structure of consumption. In a next step the projected groups of consumption goods and services are multiplied with today’s sectoral labor productivity to obtain a forecast of future sectoral employment changes. Since the labor productivity figures are available for sectors classified according the sources side of GDP, they need to be assigned to the groups of consumption goods and services. This allocation ‘key’ is not shown in the paper of Börsch-Supan (2003). Thus, this analysis uses several assumptions that offer room for discussions and arguments.

Table 2 **Effects of population aging on sectoral employment**

Sources of GDP: employment changes in all sectors (Regression results, table 1)			**Uses of GDP: employment changes in goods and services sectors (Börsch-Supan 2003b)**		
Agriculture	-	TOTAL EMPLOYMENT	Food	-	PRIVATE CONSUMPTION
Mining and Quarrying	-				
Industry					
Electricity, Gas and Water	?		Energy	+	
Manufacturing	+		Clothing and shoes	-	
			Furniture and home electronics	+	
			Health and body care	+	
			Other housekeeping goods	-	
Construction	?				
Services					
Transport, storage and communication:	?		Transport and communication	-	
Community, social and personal services	+		Education and leisure	-	
Wholesale and retail trade, restaurants and hotels	+				
Financial services, real estate and related services	+		Rent, housing	+	
			Government purchases	n.a.	
			Investment		
			Trade balance		

Source: Own calculations and Börsch-Supan, 2003b.

V. Concluding remarks

Our empirical results of effects of aging on employment are broadly consistent with those reported in the literature. However, they are statistically robust, they were derived by controlling for other important influences on sectoral employment, and they cover the whole economy, whereas the other approaches employed so far are restricted to the structure of private consumption. We find that aging **accelerates**

- the relative **decline** of sectors:
  - Agriculture,
  - Mining + Quarrying,
- the relative **growth** of sectors:
  - financial services, real estate and related services

- community, social, and personal services,
- health related services,
- possibly entertainment and services related to leisure and cultural activities.

And aging **slows down the relative decline** of manufacturing.

Hence, an overall interesting new result of our analysis is that aging causes an overall acceleration of ongoing structural change and mostly promotion of sectors with relatively low productivity growth. This may dampen somewhat long-term average productivity growth. However, considerably stronger long-term productivity growth would be needed to offset the impact in aging societies on per capita income of a decreasing number of working persons relative to the total population. Hence, this analysis has a clear policy implication, which is the support of reforms to raise productivity growth, to increase labor participation and to reduce upward pressure of aging on government expenditure and downward pressure on government revenues. Examples of reforms to raise productivity growth could be promotion of capital-funds based pension system, investment in education, investment in information and other types of technology, and increase of labor mobility. Examples of reforms to increase labor participation may be a reduction (abolishment) of incentives for early retirement, other measures to increase the average pension age and to raise participation rates, for instance of woman and through improved regulation of migration.

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