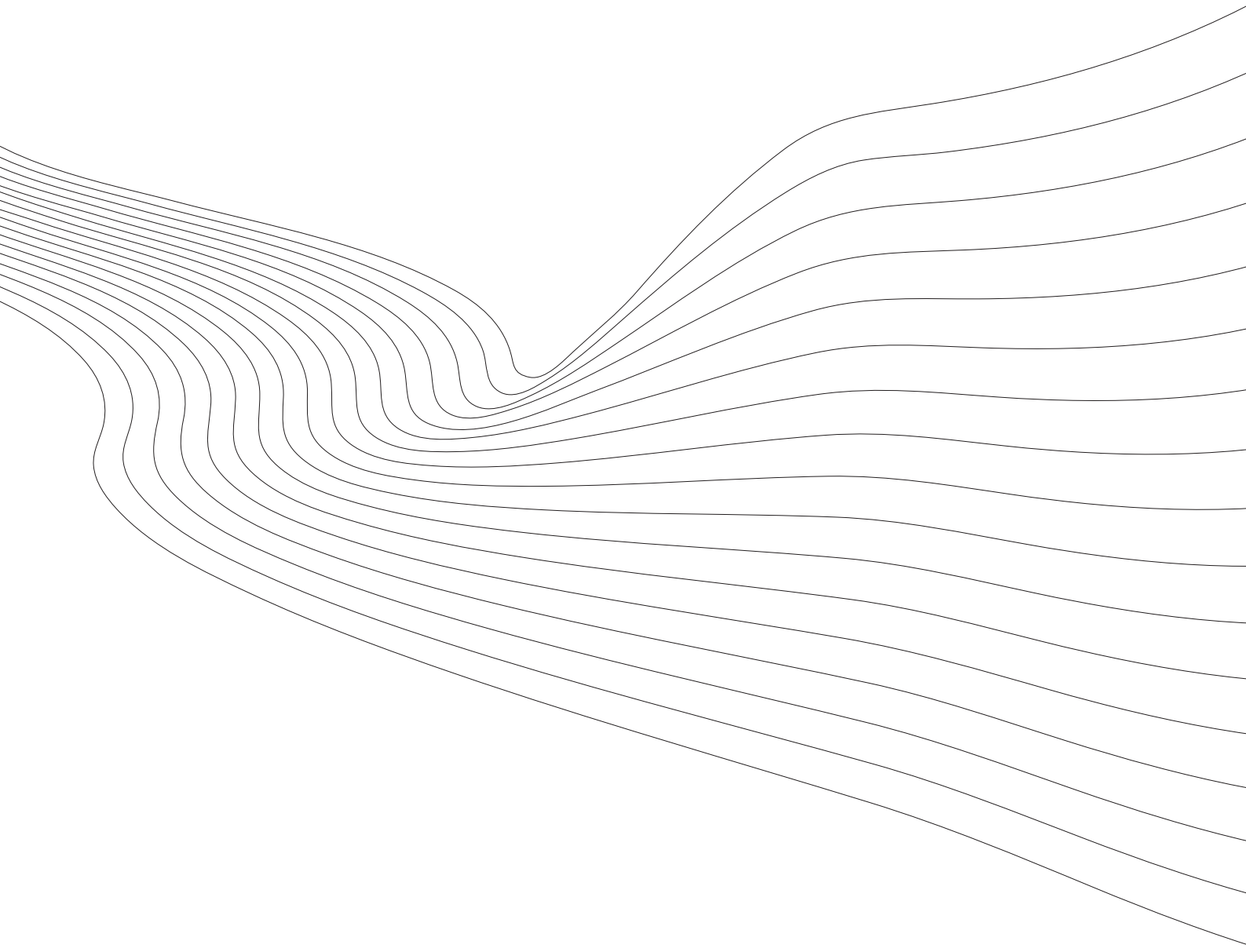
KOF

KOF Working Papers

Does Aging Influence Sectoral Employment Shares?
Evidence from Panel Data

Ulrich Thiessen, Konstantin A. Kholodilin and Boriss Siliverstovs



No. 214
December 2008

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

KOF

ETH Zurich
KOF Swiss Economic Institute
WEH D 4
Weinbergstrasse 35
8092 Zurich
Switzerland

Phone +41 44 632 42 39
Fax +41 44 632 12 18
www.kof.ethz.ch
kof@kof.ethz.ch

Does Aging Influence Sectoral Employment Shares? Evidence from Panel Data[‖]

Ulrich Thiessen [*] Konstantin A. Kholodilin [**] Boriss Siliverstovs[§]

December 11, 2008

Abstract

Our study represents a first attempt to single out the effects of aging on the entire structure of the economy that is approximated by employment shares in different sectors. We find that even after controlling for the effects of other relevant factors—e.g. income per capita, share of trade in GDP, government consumption share in GDP, population size—aging does have a statistically significant differentiated impact on the employment shares. In particular, we find that an increase in the aging proxies exerts a statistically significant adverse effect on the employment shares in agriculture, manufacturing, construction, and mining and quarrying industries. At the same time, increasing share of the elderly people in the society positively affects employment shares in community, social, and personal services as well as in the financial sector. In the simulation exercise, we illustrate the effects of aging on the employment structure within the next 45 years.

Keywords: Structural change, aging, employment shares, dynamic panel data.
JEL classification: J11, O57, C33

[‖]We are very grateful to U. Fritsche for his helpful remarks and to J.-O. Menz for his research assistance. The paper also has benefited from comments made at the following conferences: the 23rd Annual Congress of European Economic Association (EEA), Milano, Italy; the 7th Annual Meeting of the European Economics and Finance Society (EEFS), Prague, Czech Republic; the 3rd Warsaw International Economic Meeting (WIEM), Warsaw, Poland. All computations were performed using the DPD package for Ox, see Doornik et al. (2006), and using the R language, see http://cran.r-project.org/.

[*]DIW Berlin, Mohrenstrasse 58, 10117 Berlin, Germany, e-mail: uthiessen@diw.de [the corresponding author]
[**]DIW Berlin, Mohrenstrasse 58, 10117 Berlin, Germany, e-mail: kkholodilin@diw.de
[§]ETH Zurich, KOF Swiss Economic Institute, Weinbergstrasse 35, 8092 Zurich, Switzerland, e-mail: boriss.siliverstovs@kof.ethz.ch

1 Introduction

The phenomenon of aging plays an important role in shaping the modern society. It is no longer limited to a handful of rich countries but increasingly extends to the developing world. Moreover, in the last years, the aging process has intensified. Demographic projections for the next decades depict a society dominated by the gray-heads.

Acknowledging the ongoing process of population aging a still limited but growing literature investigating its effects on various economic processes emerged. One branch of the literature addresses the question whether aging increases the size of the welfare state (e.g. Shelton, 2008; Razin et al., 2002). Another strand concentrates not only on the effects of aging on aggregate economic performance (e.g. Oliveira Martins et al., 2005; Börsch-Supan, 2003b; McMorrow and Roeger, 2003, 1999; Bös and von Weizsäcker, 1988; Denton and Spencer, 1998) but also investigates particular channels through which aging affects the economy including savings and capital flows (e.g. Börsch-Supan et al., 2006; Börsch-Supan, 2001), productivity (e.g. Börsch-Supan et al., 2005; Prskawetz et al., 2005), labour demand and supply (e.g. Sapozhnikov and Triest, 2007; Prskawetz et al., 2005; Börsch-Supan, 2003a), for example. There is also a branch that investigates changes in consumption patterns induced by a growing share of elderly people in society (e.g. Buslei et al., 2007; Lührmann, 2005; Oliveira Martins et al., 2005; Börsch-Supan, 2003a,b; Serow and Sly, 1988).

The latter branch of research is of most relevance to our paper as it attempts to indirectly infer the extent to which aging affects the structure of the economy through assessing changes in private consumption caused by aging in first place. But this is obviously a limited approach and hence there is a need to estimate the effects of aging on the structure of the economy directly. As the associated re-allocation of resources among different sectors—brought about by rapid senescing of modern societies, among other things—is likely to result in considerable economic and social costs. Therefore, it is important already now to provide estimates of the potential scale and directions of this process.

To the best of our knowledge, direct assessment of the potential effects of aging on the whole economic structure and, in particular, on sectoral employment shares, attended rather little, if any, attention in the literature. The present paper intends to fill this gap by analyzing the impact of aging on the employment shares in different economic industries. In doing so, we intend to single out the effects of aging from other factors that are typically suggested in the literature which also tend to shape structure of the economy. To this end, we employ dynamic panel data analysis based on 51 countries and covering a time period from 1970 till 2004. Our results suggest that the aging variable—approximated by the ratio of elderly either to the total population or to the labor force—does exert a statistically significant differentiated impact on the employment shares when controlling for other relevant factors, e.g., income per capita, share of trade in GDP, government consumption share in GDP, population size, etc. In particular, we find that an increase in the aging proxies exerts a statistically significant adverse effect on the employment shares in agriculture,

manufacturing, construction, and mining and quarrying industries. At the same time, increasing share of elderly people in the society positively affects employment shares in community, social, and personal services as well as in the financial sector.

An additional contribution of the paper is the prediction of sectoral employment change up to 2050, which is made based on the econometric estimation results. Two scenarios are compared: a base scenario with a constant rate of change of all the variables and an alternative scenario with population growth declining and aging rate increasing over time. The comparison of both scenarios provides a net effect of aging upon the structural change. It appears that the share of employment in community, personal, and social services as well as finance services will increase, while that of manufacturing, construction, and agriculture will decrease by 2050.

The paper is structured as follows: Section 2 describes the aging process in selected OECD countries in the past, present as well as its possible development in the future, given the demographic projections. Section 3 considers the data set employed in this study. Section 4 discusses the empirical model and econometric estimation method and the results of our analysis of the effects of aging on structural change. Finally, section 5 concludes.

2 Aging process over the last 150 years

It should be noted that in most industrialized countries the increase in "dependency ratio" (as measured by the ratio between of persons not involved in the working and income-generating process relative to those that are involved) has a far longer history than usually assumed. In many industrial countries it started already several centuries ago. It is difficult, however, to illustrate this in a graph using the conventional dependency ratios, i.e., the ratios of young and/or old persons to those of 20-65 year old people. The reason is that in such ratios the only criterion used to distinguish between those involved and not involved in the income-generating process is the age. However, in the former times, a larger share of the persons younger than 20 years were working, i.e., had a gainful occupation, than today. Moreover, in many countries the share of young people enrolled in higher education has been steadily growing and the average age, at which gainful employment starts, has been correspondingly increasing. In addition, 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. Therefore, taking all these factors into account, one may conclude that in many industrialized countries the conventional young-age dependency ratio underestimates the scale of the long-term phenomenon of increasing young dependency. This also implies that the rising long-term trend of the total dependency ratio may be somewhat underestimated. Hence, the statistical indicators of dependency, at least those covering the late 19th century

and early 20th century as well as the projected[1]. dependency ratios, have to be interpreted with a great care.

As an example of the aging process in a typical industrialized country a case of Germany is considered in Figure 1. It shows three dependency ratios and the ratios of the old and young to the whole population over the period 1871-2050. One can observe that the whole period was characterized by two demographic changes going in the opposite directions. Firstly, the ratio of the young to the total population (young age dependency ratio) has been steadily decreasing from about 44% (84%) in the end of 19th century to 20% (33%) in 2005. For 2050, a further decrease up to 15% (29%) is projected. Secondly, the ratio of the elderly to the total population (old age dependency ratio) has been almost uninterruptedly increasing from around 9% (5%) in the late 19th century to 19% (32%) in 2005. According to demographic projections, in 2050 it should achieve 33% (62%). From the beginning of the sample and up to the early 1930s, dependency ratio experienced a dramatic decrease from 93% to about 65%, at which level it stabilized for about 80 years. The main contributor to this tendency was a decreasing share of the young people. However, due to the growth of the elderly ratio accelerated in the recent years the dependency ratio is projected to increase in the forecast period and attain 94% by 2050.

In the recent decades, the increase of the elderly ratio has been a characteristic feature of the majority of the industrialized countries. Figure 2 illustrates this for the selected OECD countries and an average of EU15 members. For the sake of readability of the graph we divided it in two panels: one showing the countries where the ratio of elderly is projected to stabilize in the period after 2030 and another one displaying countries where it is projected to increase further. Notice that the Asian countries, such as Japan and South Korea are experiencing the largest increase in the ratio of elderly to total population among all OECD countries. In 2050 the elderly ratio in Japan and South Korea should be respectively 8 and 12 times bigger than it was in 1950. The smallest increase is projected in France, Norway, Sweden, Ireland, and USA where the elderly ratio will be 2.3-2.5 times larger than in 1950. It is slightly less than the average of EU15, which is about 3 times. In 2050, the highest elderly ratio among the selected countries, is expected to be achieved in Japan, South Korea and Spain (39.6%, 38.2%, and 35.7%, correspondingly), whereas the lowest elderly ratio is expected for Turkey, USA, and Mexico (17.0%, 20.6%, 21.1%, correspondingly).

[1]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.

3 Data

Our data set includes a maximum of 54 selected developing and developed economies[2]. We use the 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. In our analysis we use employment shares in the following nine sectors: agriculture (lfa), manufacturing (lfm), mining and quarrying (lfmq), electricity, gas and water (lfe), construction (lfc), wholesale, retail trade, restaurants and hotels (lfw), transport, storage, communication (lft), financial services, real estate and related services (lff), and community, social, and personal services (lfcs).[3] It is rather well documented in the literature that rise in the per capita income is typically accompanied by the following changes of relative employment shares in the nine sectors in question. First, one observes a continuous decline in the primary and secondary sectors here represented by agriculture, manufacturing, mining and quarrying, energy, and construction. Second, employment shares are continuously rising with increasing per capita income in the tertiary sector represented by wholesale, retail trade, restaurants and hotels, transport, storage, communication, financial services, real estate and related services, and community, social, and personal services[4].

The explanatory variables include per capita income (gdppc), measured in purchasing power parities, the size of the economies proxied by population (pop). We also include proxies for "openness" (tr), i.e., the sum of exports and imports as a ratio to GDP, a variable to capture the effect of government policies, namely the government consumption expenditure share (gcogdp), share of exports of agricultural products in exports of merchandise goods (xaxme). However, our variable of primary interest is aging, represented by the two proxies already described, namely the ratio of elderly either to the total population (age) or to the labor force (odep). In the following analysis, we use the logarithmic transformation of the per capita income and of the total population variables. The rest of the variables, including dependent variables, are left intact since these are already expressed as percentage shares.

[2]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.

[3]The employment data have a residual due to unexplained employment ("activities not adequately defined"), i.e., the shares do not always add up to one and hence our dataset does not fulfill this aggregation constraint. At the same time, using this dataset we are able to track changes for most of the employment in the economy as the unexplained portion is relatively small (below 5%). This also holds with regard to our simulations reported below in Section 4.3.

[4]The latter sector includes government.

4 Empirical findings

4.1 Econometric model

In the following, we estimate the parameters of the following dynamic panel data model

$$emp_{it} = \delta emp_{i,t-1} + \boldsymbol{\beta'} \boldsymbol{X_{it}} + \lambda aging_{it} + \boldsymbol{\theta'} \boldsymbol{D_{it}} + u_{it} \tag{1}$$

where emp_{it} is an employment share in either of the nine industries in question, $\boldsymbol{X_{it}}$ is a $K \times 1$ vector of the explanatory variables which were discussed in Section 3 above. The variable $aging_{it}$ represents our variable of interest and the corresponding coefficient measures the impact of changing proportion of the elderly people in the society on the employment shares in different industries. As usual, a vector of the cross-sectional fixed effects, represented by $\boldsymbol{D_{it}}$, can be added to the regression model (1). Note that in order to account for temporal correlation of the dependent variable, we include its first lag in the model. Since we use yearly data, such lag length proved to be appropriate for our empirical modelling.

It is well-known that in the presence of the fixed effects, estimation of the parameters of the dynamic panel data model is subject to estimation bias, which can be quite severe if the panel time dimension is rather small (Nickell, 1981; Kiviet, 1995). As the solution to the estimation bias, a number of panel data estimators have been proposed including the instrumental estimator of Anderson and Hsiao (1982) that uses the first-differences of the data in order to eliminate the fixed effects. Expanding on the Anderson and Hsiao (1982) estimator, Arellano and Bond (1991) show that there are many more instruments available within the GMM framework than used by conventional instrumental variable estimation. The GMM estimator of Arellano and Bond (1991) is the two-step estimator. In the first step, the parameters are estimated using the identity matrix for weighting the moment conditions. In the second step, an asymptotically more efficient estimation is conducted by optimal weighting of the moment condition using the first-step estimation results. As a consequence, the efficiency of GMM-based estimators is greatly enhanced when compared to that of the Anderson and Hsiao (1982) estimator.

However, as Baltagi et al. (2000) point out, the estimators of Anderson and Hsiao (1982) and Arellano and Bond (1991) may eliminate the estimation bias, but with a large loss of information. The application of the first-difference transformation destroys the economic structure formed between the levels of the variables across the time series dimension. Fortunately, the two-step GMM estimator developed by Arellano and Bover (1995) addresses this issue by employing both the first differences as well as the levels of the variables by specifying the appropriate sets of instruments for both types of equations. Below, we estimate the parameters of equation (1) by means of the two-step GMM estimator suggested in Arellano and Bover (1995). Observe that our inference on the significance of the estimated parameters is based on small sample correction of Windmeijer (2000) applied to the estimated covariance matrix in the second step of the corresponding GMM

procedure.

As noted in Phillips and Sul (2007), performance of the GMM estimators can be unsatisfactory in situations where time series exhibit high persistence. Hence, in order to obtain sensible results we need to check how persistent is the dependent variable. In order to check this, we have estimated the first-order panel autoregressive model for each of the nine industrial sectors using the Arellano and Bover (1995) GMM estimator. The results of our exercise provide very strong evidence that our dependent variable is highly persistent: the estimated value of the autoregressive parameter is within the range from 0.971 till 0.995 for employment shares in eight sectors, and for the 'financial service' sector its value is 1.005, indicating non-stationarity of our data. A similar pattern of high temporal persistence is also observed for the explanatory variables collected in $\boldsymbol{X_{it}}$.

Given our findings, one may consider testing for the presence of unit roots in the variables of interest and, subsequently, to test for presence of cointegration. However, given very unbalanced nature of our data and the significant share of countries where the time dimension either is smaller or of a comparable magnitude to the number of the explanatory variables, testing for cointegration in our data set would involve omission of substantial number of countries (i.e., observations) and hence it may bias our results. Instead, we have chosen to transform the variable in question by taking first differences. Hence the estimated model takes the following form

$$\Delta emp_{it} = \delta \Delta emp_{i,t-1} + \boldsymbol{\beta'} \boldsymbol{\Delta X_{it}} + \lambda \Delta aging_{it} + \vartheta_{it} \tag{2}$$

where Δ is the first-difference operator. Observe that such transformation implies that application of the GMM estimator of Arellano and Bover (1995) involves the moment conditions among the first-differences of the levels of the original variables as well as among their second-differences. An additional advantage of estimating model in the first differences is that in doing so we avoid spurious regression caused by non-stationarity of the modelled variables. As usual, the validity of the moment conditions and of the model assumptions is checked with the Sargan over-identification test as well as with the Arellano-Bond first-and second-order residual autocorrelation tests.

4.2 Estimation results

Tables 1 and 2 contain the estimation results of our panel data regressions using the share of elderly in total population and in the labor force, respectively. First, one observes that both set of regressions yield very similar results, i.e., the coefficient values and their significance for all explanatory variables except our proxies for the aging variable match each other quite closely. The difference in the values of the estimated coefficients of our aging proxies is due to different scaling, i.e., we scale the same variable (number of elderly) either by total population or by labor force. Second, according to the model specification tests, the estimated regressions do not deviate from model assumptions: we cannot reject the null hypothesis of the validity of

moment conditions according to the Sargan test and, as expected, the Arellano-Bond autocorrelation tests indicate the presence of the first-order autocorrelation in the panel regression residuals. At the same time no second-order autocorrelation is detected in the regression residuals.

The own lag of the dependent variable is significant in five out of nine sectors and it takes negative values for all sectors. Thus, the absolute value of the autoregressive parameter is much less than unity indicating that by taking the first-difference transformation of our data we have solved the problem of extremely high persistence and/or of non-stationarity. We also find that our estimation results suggest that changes in employment shares in agriculture are negatively correlated with changes in the per capita income, whereas there is a positive association between changes in employment shares in manufacturing, construction, and financial sector on the one hand and changes in the per capita income on the other hand. As the coefficient estimate corresponding to the square of the per capita income variable turned out to be insignificantly different from zero in all sectors but construction, we find no statistical evidence for the presence of nonlinear effects between changes in the per capita income and in employment shares for these eight sectors. It is also interesting to note that neither changes in trade share nor in government consumption share have significant effects on the changes of the sectoral employment shares.

Next, we assess the impact of our aging variables on the employment shares in the different sectors. Since, the both sets of the estimation results are very similar we restrict our discussion to the results presented in Table 1, i.e., for the share of elderly to the total population. First, we notice that the corresponding variable is significant for six sectors out of nine. We find that the corresponding parameter estimate is not significantly different from zero for electricity, gas and water (lfe), wholesale and retail trade, restaurants and hotels (lfw) and transport, storage, and communication (lft) sectors. At the same time, we find that the increase in proportion of elderly people has a statistically significant negative impact on employment shares in such sectors as agriculture, manufacturing, mining and quarrying, and in construction. The strongest effect is realized in the former two sectors. In two sectors, financial and related services and community, social, and personal services, we find that changes in share of the elderly people positively affects employment shares. Thus, aging appears to have a statistically significant differentiated effect on employment shares in various sectors. The overall impact of aging is that it promotes ongoing structural change by contributing further to shrinking agricultural and manufacturing shares in the economy and, at the same time, to enhancing employment in service and financial industry. This result holds for both proxies that we use in order to measure aging, i.e., the share of elderly in total population as well as in the labor force.

It instructive to consider the effect of one standard deviation change in the aging proxies on the sectoral employment shares expressed in terms of the standard deviation of the dependent variable[5]. In doing so, we are able to assess the relative importance of aging for employment shares in each industry. As seen

[5]Observe that due to the non-stationarity of the variables of interest in levels (recall that the sample variance of the nonstationary variable increases without limit) such exercise is only possible after performing a stationarity transformation of these variables by taking first differences.

from Table 3, the effect of aging is mostly pronounced for financial, real estate and related services (lff). One standard deviation in Δage variable results in increase of about 0.163 (0.173) standard deviations in the employment share in financial, real estate and related services, depending on the aging proxy. The community, social, and personal services (lfcs) sector is second in line with the corresponding impact being about 0.113 (0.097) standard deviations. Population aging had also a comparatively larger impact on the employment shares in the manufacturing sector (lfm) — -0.090 (-0.083). For the remaining three sectors, for which we found the significant coefficient estimates (i.e., lfa, lfmq, and lfc), the impact of aging is about of the same magnitude, in the range of -0.050 — -0.064, depending on the aging proxy and the industry.

4.3 Simulation results

In this subsection, we use the estimation results of the previous section in order to predict the effects of aging upon the structural change until 2050. The simulation is carried out using two alternative scenarios, which differ only in their assumptions concerning demographic developments. The simulations are performed for both aging variables: share of elderly in the total population (age) and share of elderly in the labor force (odep).

Specifically, the base scenario assumes that all regressors including the respective aging variable are evolving during the forecast period 2005-2050 at the average growth rate they had in the estimation period 1970-2004. In the alternative scenario, the demographic variables, which are population growth and the respective aging variable, are assumed to evolve according to the medium variant projections taken from the World Population Prospects: The 2006 Revision[6].

Figure 3 compares the actual demographic trends (population growth and the change in two aging variables) observed on average over the estimation period to the projected by the UN demographic trends over the forecast period. As can be seen, the population growth rate is expected to be substantially lower in all of the sample countries[7] during the forecast period (about 0.6% on median) compared to the estimation period (1.4% on median), whereas just the opposite is true for both aging variables. Thus, the median growth rate of elderly to total population ratio is 0.073% in 1970-2004 and 0.248% in 2005-2050, while the median growth rate of elderly to labor force ratio is 0.072% in 1970-2004 and 0.433% in 2005-2050. It means that the alternative scenario is based upon lower population growth rates and higher aging growth rates than the base scenario. Hence, the difference between the sectoral employment shares predicted under these two scenarios measure the net effect of aging.

The predicted net effect of aging upon the sectoral employment structure is summarized in Figure 4. For each sector, a boxplot is depicted that shows the distribution of difference between the alternative and the

[6]See http://www.un.org/esa/population/unpop.htm. The data in this database are available at 5-year frequency and had therefore to be interpolated to the yearly frequency using the natural cubic spline, which is a standard interpolation technique in demographics.

[7]Due to the lack of the balanced data Dominican Republic was left out from the sample.

base scenario across 50 countries. Thus, the negative (positive) difference implies that the corresponding sector's share declined (increased) stronger under the alternative than under the base scenario. The upper panel corresponds to the "age" variable, while the lower panel corresponds to the "odep" variable. The results are very similar for both variables, which is no surprise, given similar estimation results. Firstly, two sectors are expected to benefit from the aging process, namely: "community, social, and personal services" and "financial services". The employment shares in these two services sectors are strongly positively affected by aging: the median differences in 2050 in the former sector are between 8.7 for "age" variable and 9.5 percentage points for "odep" variable, while those for the latter sector are between 6.3 and 8.0 percentage points and very few observations are below zero. Secondly, there are three sectors that can be denoted as losers of aging process, namely "agriculture" (a median aging effect between -1.6 and -2.2 percentage point), "construction" (between -2.8 and -3.4 percentage points) and "manufacturing" (between -4.8 and -5.0 percentage points). Thirdly, the employment shares of other four sectors are expected to be on average unaffected by aging. These sectors include "wholesale trade", "electricity" as well as "mining and quarrying".

Thus, our simulations show that virtually all countries (since our sample includes both rich and poor economies) are expected to go through substantial structural changes in the next 45 years, provided the aging will evolve as predicted in the UN World Population Prospect. Therefore, these countries have to adjust their economies if they want to face as smooth transition process as possible. In particular, a due attention is to be paid to the loser sectors such as manufacturing, construction, and agriculture. There might be needed active structural policy measures aimed at facilitating the transfer of the working force from these sectors to the sectors that are expected to win in the course of aging process. In some cases, a question must be raised, whether it really makes sense to keep the industries without the future wasting huge amounts on maintaining them alive.

5 Conclusion

In this paper, we investigated the relationship between the changes in the demographic structure of the population and the employment shares in the various industries based on the unbalanced panel of 54 countries covering the longest time period from 1970 till 2004.

Our results suggest that the aging variable approximated by the ratio of elderly either to the total population or to the labor force does have a statistically significant differentiated impact on the employment shares when controlling for other relevant factors, e.g., income per capita, share of trade in GDP, government consumption share in GDP, population size, etc. In particular, we find that an increase in the aging proxies exerts a statistically significant adverse effect on the employment shares in agriculture, manufacturing, construction, and mining and quarrying industries. At the same time, increasing share of the elderly people in the society positively affects employment shares in community, social, and personal services as well as

in the financial sector. Moreover, we also find that the effect of aging has been mostly pronounced in the financial, real estate, and related services as well as in the community, social, and personal services, followed by the manufacturing sector. Hence we conclude that aging further accelerates the ongoing structural change usually associated with an ever increasing role of the services sector at the expense of traditional sectors like agriculture and manufacturing.

This result may appear unsurprising but so far our study represents the first attempt to document and, moreover, to quantify the effects of aging on the whole economic structure of the economy approximated here by the employment shares in various industries. For example, this paper makes predictions of the scale and direction of the effects of aging on sectoral structure. It is shown that solely due to aging—under the *ceteris paribus* conditions—such sectors as "manufacturing", "construction", and "agriculture" will shrink in terms of their employment shares relative to the "personal and communal services" and "financial services". The negative effects of aging can be on median as large as -5.5 percentage points, whereas the positive effects can attain on median 9.5 percentage points by 2050. These are very considerable when it comes to the absolute employment figures. Moreover, they concern both rich as well as poor countries. Therefore, such structural change, albeit extended over several decades, may imply enormous social and economic costs. In order to minimize them and make the transition process as smooth as possible structural policy measures on behalf of the governments might be needed.

References

Anderson, T. W. and C. Hsiao (1982). Estimation of dynamic panel models with error components. *Journal of the American Statistical Association 76*, 74–82.

Arellano, M. and S. R. Bond (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *Review of Economic Studies 58*, 277–97.

Arellano, M. and O. Bover (1995). Another look at the instrumental-variable estimation of error-components models. *Journal of Econometrics 68*, 29–52.

Baltagi, B. H., J. M. Griffin, and W. Xiong (2000). To pool or not to pool: Homogeneous versus heterogeneous estimators applied to cigarette demand. *The Review of Economics and Statistics 82*(1), 117–126.

Börsch-Supan, A. (2001). Aging and international capital flows. NBER Working Paper 8553.

Börsch-Supan, A. (2003a). Gesamtwirtschaftliche Folgen des demographischen Wandels. Institut für Angewandte Wirtschaftsforschung Report 31 (1), Tübingen.

Börsch-Supan, A. (2003b). Labor market effects of population aging. *Review of Labour Economics and Industrial Relations 17*, 5–44.

Börsch-Supan, A., I. Düzgün, and W. Matthias (2005). Altern und Produktivität: Zum Stand der Forschung. Mannheim Research Institute for the Economics of Aging, Working Paper No. 73.

Börsch-Supan, A., A. Ludwig, and J. Winter (2006). Ageing, pension reform and capital flows: A multi-country simulation model. *Economica 73*, 625–658.

Bös, D. and R. von Weizsäcker (1988). Economic consequences of an aging population. Discussion Paper Serie A 191, University of Bonn, Germany.

Buslei, H., E. Schulz, and V. Steiner (2007). Effects of demographic change on private demand for goods and services in Germany until 2050. DIW Berlin Politikberatung kompakt 26, Berlin.

Denton, F. T. and B. G. Spencer (1998). Economic costs of population aging. Independence and Economic Security of the Older Population Research Papers 32, McMaster University.

Doornik, J. A., M. Arellano, and S. Bond (2006). Panel data estimation using DPD for Ox. Mimeo.

Kiviet, J. F. (1995). On bias, inconsistency and efficiency of some estimators in dynamic panel data models. *Journal of Econometrics 68*, 53–78.

Lührmann, M. (2005). Population aging and the demand for goods and services. MEA discussion paper series 05095, Mannheim Research Institute for the Economics of Aging (MEA), University of Mannheim.

McMorrow, K. and W. Roeger (1999). The economic consequences of ageing populations. European Economy - Economic Papers 138, Commission of the EC, Directorate-General for Economic and Financial Affairs (DG ECFIN), Brussels.

McMorrow, K. and W. Roeger (2003). Economic and financial market consequences of ageing populations. European Economy - Economic Papers 182, Commission of the EC, Directorate-General for Economic and Financial Affairs (DG ECFIN), Brussels.

Nickell, S. (1981). Biases in dynamic models with fixed effects. *Econometrica 49*, 1417–1426.

Oliveira Martins, J., F. Gonand, P. Antolin, C. de la Maisonneuve, and K.-Y. Yoo (2005). The impact of ageing on demand, factor markets and growth. OECD Economics Department Working Papers 420, OECD Economics Department, Paris.

Phillips, P. C. and D. Sul (2007). Bias in dynamic panel estimation with fixed effects, incidental trends and cross section dependence. *Journal of Econometrics 127*(1), 162–188.

Prskawetz, A., T. Fent, and R. Guest (2005). Workforce ageing and labour productivity: the role of supply and demand of labour in the G7. paper presented at the European Population Conference 2006, Liverpool.

Razin, A., E. Sadka, and P. Swagel (2002). The aging population and the size of the welfare state. *Journal of Political Economy 110*(4), 900–918.

Sapozhnikov, M. and R. K. Triest (2007). Population aging, labor demand, and the structure of wages. Federal Reserve Bank of Boston, Working paper No. 07-8.

Serow, W. and D. Sly (1988). Economic aspects of structural change in the older population of the United States: 1980-2020. Florida State University Working Paper No. 46.

Shelton, C. A. (2008). The aging population and the size of the welfare state: Is there a puzzle? *Journal of Public Economics 92*(2), 647–651.

Windmeijer, F. (2000). Moment conditions for fixed effects count data models with endogenous regressors. *Economics Letters 68*(1), 21–24.

Table 1: Estimation results: the aging proxy — the share of elderly in total population

	Δlfa	Δlfm	Δlfmq	Δlfe	Δlfc	Δlfw	Δlft	Δlff	Δlfcs
Own lag	-0.146 ***	-0.010	-0.025	-0.176 ***	0.022	-0.090 *	-0.158 **	-0.250 **	-0.128
	(0.055)	(0.037)	(0.049)	(0.052)	(0.054)	(0.050)	(0.073)	(0.118)	(0.104)
Δlgdppc	-8.024 ***	3.087 *	0.209	-0.102	3.951 ***	0.780	0.382	0.934	-1.413
	(1.790)	(1.610)	(0.150)	(0.127)	(0.830)	(1.126)	(0.472)	(0.602)	(2.083)
$(\Delta\text{lgdppc})^2$	3.774	-28.693	-1.588	0.257	-32.434 *	11.024	4.013		-7.355
	(13.590)	(36.680)	(1.960)	(3.392)	(17.310)	(26.580)	(10.660)		(22.830)
Δtr	0.018 *	0.004	0.001	0.000	-0.001	-0.006	-0.001	0.002	0.003
	(0.009)	(0.008)	(0.001)	(0.001)	(0.003)	(0.005)	(0.001)	(0.003)	(0.007)
Δlpop	-10.154 ***	-2.674	0.055	0.017	4.169 *	5.771	0.695	3.677 **	-1.588
	(2.873)	(3.317)	(0.431)	(0.115)	(2.256)	(4.488)	(1.044)	(1.702)	(5.435)
Δgcogdp	-0.052	-0.002	0.009	0.001	-0.015	0.021	0.018	0.016	0.048
	(0.039)	(0.073)	(0.006)	(0.004)	(0.025)	(0.030)	(0.015)	(0.022)	(0.047)
Δxaxme	0.046								
	(0.037)								
Δage	-0.688 **	-0.805 **	-0.063 ***	-0.024	-0.239 **	0.321	0.032	0.831 ***	1.077 ***
	(0.314)	(0.336)	(0.020)	(0.025)	(0.115)	(0.253)	(0.066)	(0.174)	(0.399)
$\widehat{\sigma}$	1.332	1.020	0.139	0.198	0.460	0.693	0.290	0.498	1.050
N	50	51	51	51	51	51	51	51	51
T_{max}	28	28	28	28	28	28	28	27	28
T_{min}	3	3	3	3	3	3	3	3	3
Obs	825	862	861	862	862	862	862	852	862
Sargan	46.43 [1.000]	43.21 [1.000]	41.15 [1.000]	46.58 [1.000]	42.65 [1.000]	44.33 [1.000]	48.39 [1.000]	46.32 [1.000]	46.61 [1.000]
AR(1)	-2.38 [0.017]**	-2.15 [0.032]**	-2.67 [0.008]***	-3.90 [0.000]***	-4.00 [0.000]***	-3.54 [0.000]***	-3.58 [0.000]***	-1.97 [0.049]**	-2.26 [0.024]**
AR(2)	0.13 [0.900]	1.18 [0.239]	-0.43 [0.668]	-0.50 [0.619]	1.62 [0.105]	-1.01 [0.312]	0.61 [0.541]	-1.31 [0.189]	-1.02 [0.307]

The sectors are named as follows: agriculture (lfa), manufacturing (lfm), mining and quarrying (lfmq), electricity, gas and water (lfe), construction (lfc), wholesale, retail trade, restaurants and hotels (lfw), transport, storage, communication (lft), financial services, real estate and related services (lff), and community, social, and personal services (lfcs).
Table entries are estimated coefficients with the corresponding standard errors in parentheses.
'***', '**', and '*' denote 1%, 5%, and 10% significance levels, respectively.

Table 2: Estimation results: the aging proxy — the share of elderly in the labor force

	Δlfa	Δlfm	Δlfmq	Δlfe	Δlfc	Δlfw	Δlft	Δlff	Δlfcs
Own lag	-0.148 ***	-0.010	-0.025	-0.184 ***	0.019	-0.089 *	-0.166 **	-0.249 **	-0.127
	(0.056)	(0.040)	(0.049)	(0.051)	(0.055)	(0.050)	(0.077)	(0.119)	(0.105)
Δlgdppc	-8.135 ***	2.887 *	0.196	-0.099	4.023 ***	0.846	0.331	1.093 *	-1.306
	(1.802)	(1.578)	(0.159)	(0.136)	(0.836)	(1.083)	(0.518)	(0.628)	(2.112)
$(\Delta\text{lgdppc})^2$	-0.670	-27.789	-1.942	0.337	-34.016 *	19.987	5.197		-5.120
	(14.230)	(32.550)	(2.508)	(4.365)	(18.790)	(27.970)	(11.140)		(23.560)
Δtr	0.018 *	0.003	0.001	0.000	-0.002	-0.007	-0.001	0.002	0.003
	(0.010)	(0.009)	(0.001)	(0.001)	(0.003)	(0.006)	(0.001)	(0.003)	(0.007)
Δlpop	-10.301 ***	-3.608	0.015	0.082	3.800	5.613	0.867	4.013 **	0.089
	(3.026)	3.734)	(0.355)	(0.200)	(2.770)	(4.019)	(1.121)	(1.797)	(6.620)
Δgcogdp	-0.063 *	-0.008	0.008	0.003	-0.016	0.024	0.020	0.018	0.055
	(0.036)	(0.071)	(0.007)	(0.004)	(0.024)	(0.030)	(0.016)	(0.023)	(0.046)
Δxaxme	0.049								
	(0.038)								
Δodep	-0.394 **	-0.451 **	-0.042 ***	-0.017	-0.168 **	0.146	0.007	0.533 ***	0.560 **
	(0.181)	(0.190)	(0.014)	(0.013)	(0.074)	(0.135)	(0.037)	(0.109)	(0.247)
$\widehat{\sigma}$	1.332	1.021	0.139	0.198	0.460	0.693	0.290	0.499	1.053
N	50	51	51	51	51	51	51	51	51
T_{max}	28	28	28	28	28	28	28	27	28
T_{min}	3	3	3	3	3	3	3	3	3
Obs	825	862	861	862	862	862	862	852	862
Sargan	46.9 [1.000]	44.39 [1.000]	43.64 [1.000]	46.78 [1.000]	43.35 [1.000]	42.68 [1.000]	49.18 [1.000]	46.43 [1.000]	46.92 [1.000]
AR(1)	-2.37 [0.018]**	-2.14 [0.033]**	-2.70 [0.007]***	-3.90 [0.000]***	-3.97 [0.000]***	-3.58 [0.000]***	-3.48 [0.000]***	-1.97 [0.049]**	-2.25 [0.024]**
AR(2)	0.12 [0.902]	1.17 [0.240]	-0.43 [0.664]	-0.63 [0.530]	1.59 [0.112]	-1.01 [0.315]	0.53 [0.597]	-1.31 [0.190]	-1.00 [0.319]

The sectors are named as follows: agriculture (lfa), manufacturing (lfm), mining and quarrying (lfmq), electricity, gas and water (lfe), construction (lfc), wholesale, retail trade, restaurants and hotels (lfw), transport, storage, communication (lft), financial services, real estate and related services (lff), and community, social, and personal services (lfcs).
Table entries are estimated coefficients with the corresponding standard errors in parentheses.
'***', '**', and '*' denote 1%, 5%, and 10% significance levels, respectively.

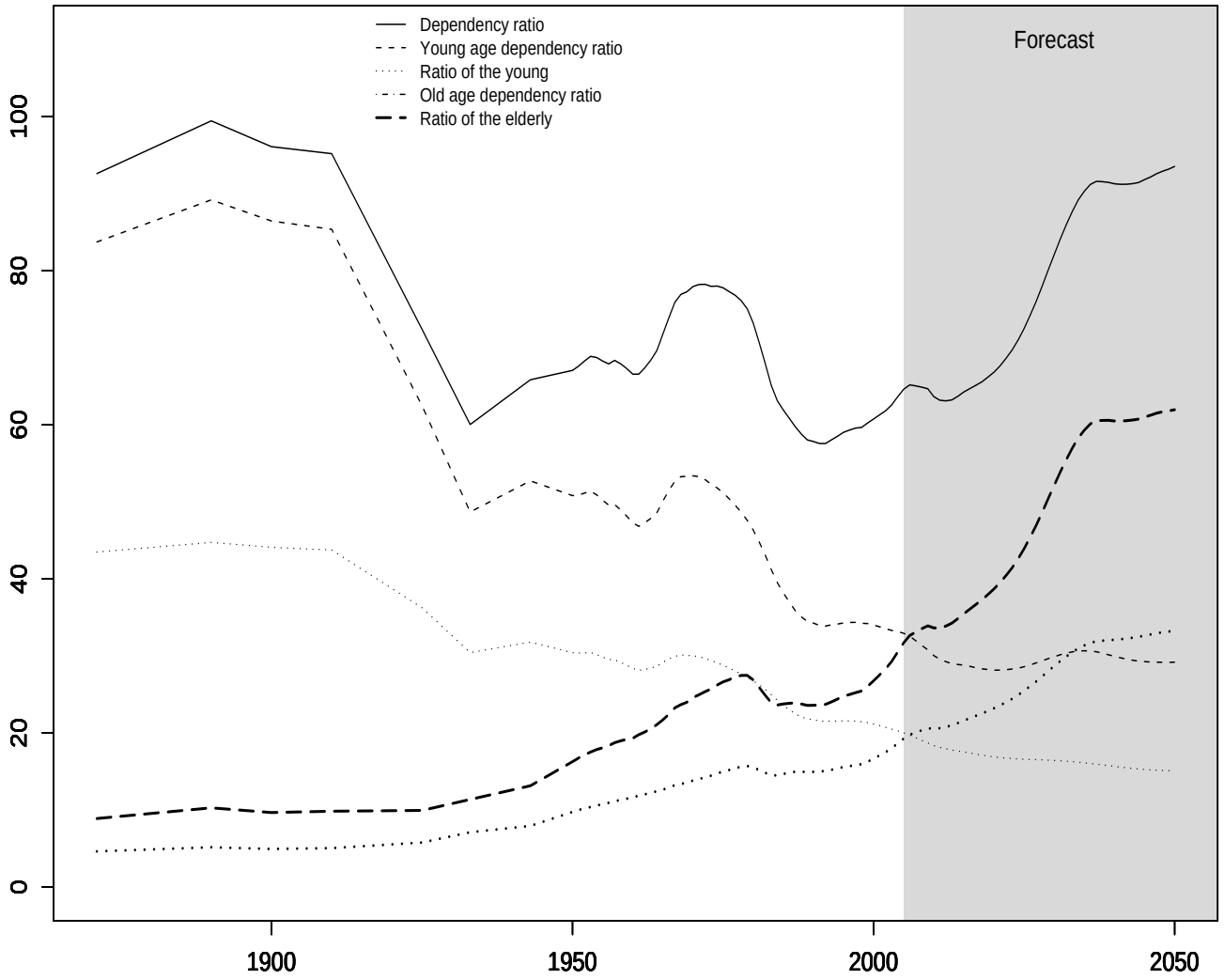
Table 3: Estimated effect of one standard deviation change in aging proxies (Row 5) in terms of standard deviations of the dependent variable

Row		Δlfa	Δlfm	Δlfmq	Δlfe	Δlfc	Δlfw	Δlft	Δlff	Δlfcs
1	coef. Δage	-0.688	-0.805	-0.063	-0.024	-0.239	0.321	0.032	0.831	1.077
2	st.dev. Δage	0.113	0.113	0.113	0.113	0.113	0.113	0.113	0.113	0.113
3	product (row2*row3)	-0.078	-0.091	-0.007	-0.003	-0.027	0.036	0.004	0.094	0.122
4	st.dev. of dep. var.	1.481	1.017	0.141	0.186	0.491	0.728	0.299	0.577	1.085
5	ratio (row3/row4)	-0.053	-0.090	-0.051	-0.015	-0.055	0.050	0.012	0.163	0.113

Row		Δlfa	Δlfm	Δlfmq	Δlfe	Δlfc	Δlfw	Δlft	Δlff	Δlfcs
1	coef. Δodep	-0.394	-0.451	-0.042	-0.017	-0.168	0.146	0.007	0.533	0.560
2	st.dev. Δodep	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188
3	product (row2*row3)	-0.074	-0.085	-0.008	-0.003	-0.032	0.027	0.001	0.100	0.105
4	st.dev. of dep. var.	1.481	1.017	0.141	0.186	0.491	0.728	0.299	0.577	1.085
5	ratio (row3/row4)	-0.050	-0.083	-0.056	-0.017	-0.064	0.038	0.004	0.173	0.097

The upper (lower) panel contains the estimated effect of one standard deviation change in the share of elderly in total population (in the labour force) on the sectoral employment shares as expressed in terms of standard deviation, see the row 5 in the respective panel. Both aging proxies and sectoral employment shares have been transformed to stationarity by taking first difference.
For description of the sectors see notes in Tables 1 or 2.

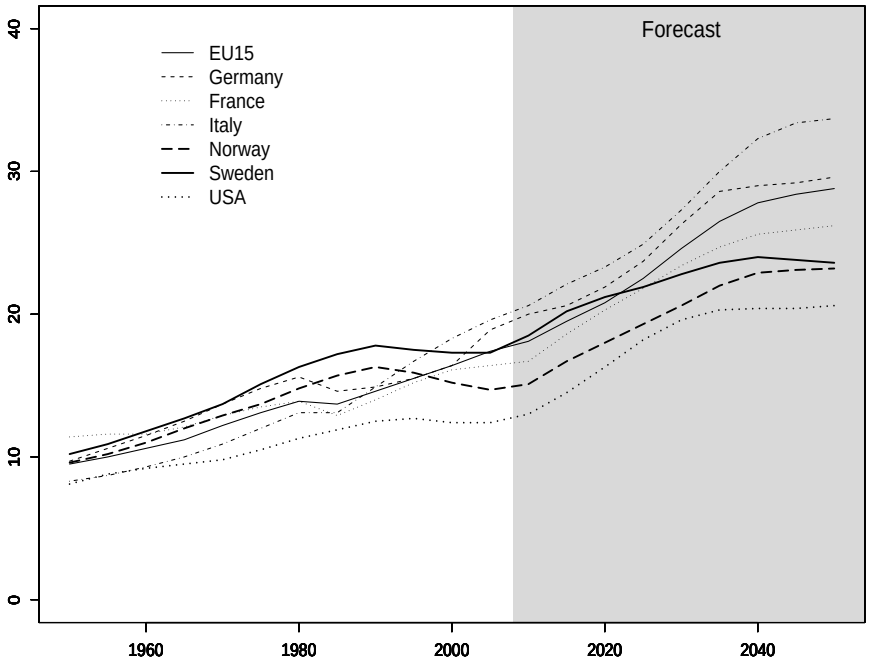
Figure 1: Population structure in Germany 1871 - 2050



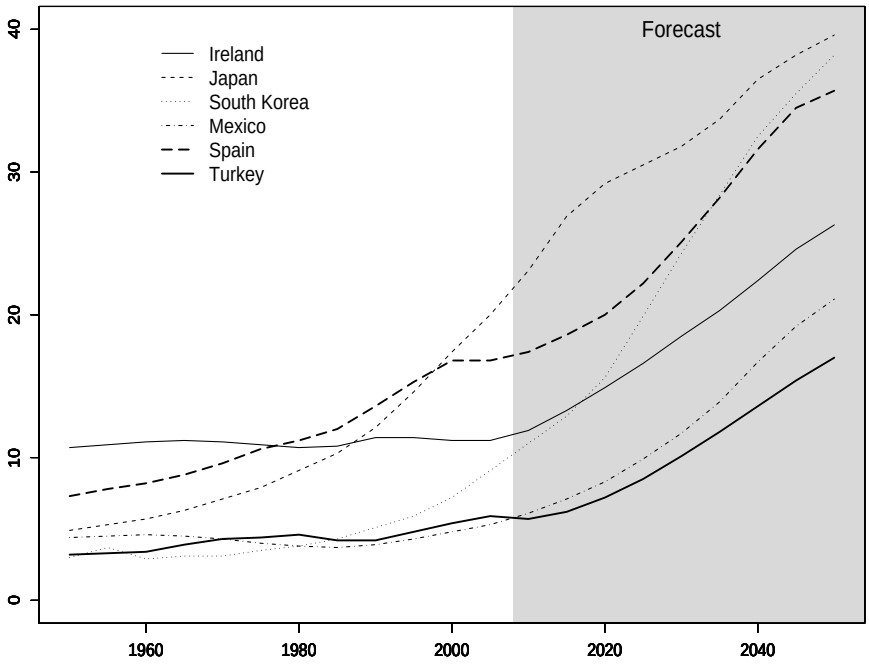
Source: World Development Indicators

Figure 2: Ratio of population aged 65 and above to total population for selected OECD countries 1950 - 2050. Source: World Development Indicators.

(a) Countries with stabilization of aging in the forecast period



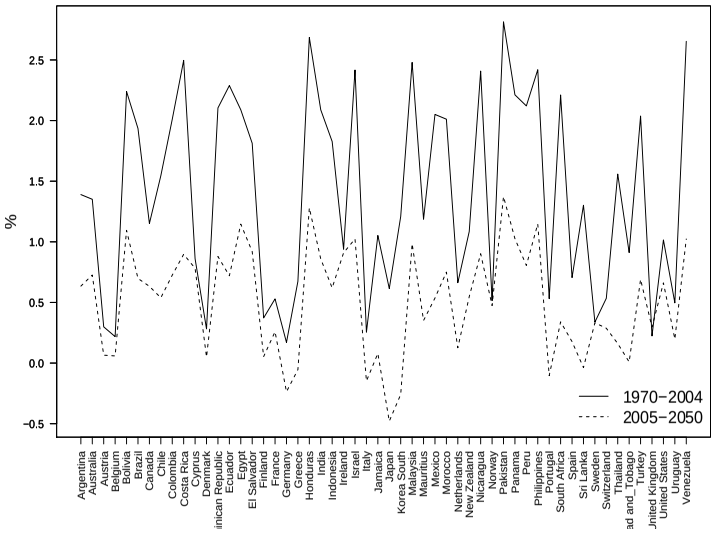
(b) Countries with continuation of aging in the forecast period



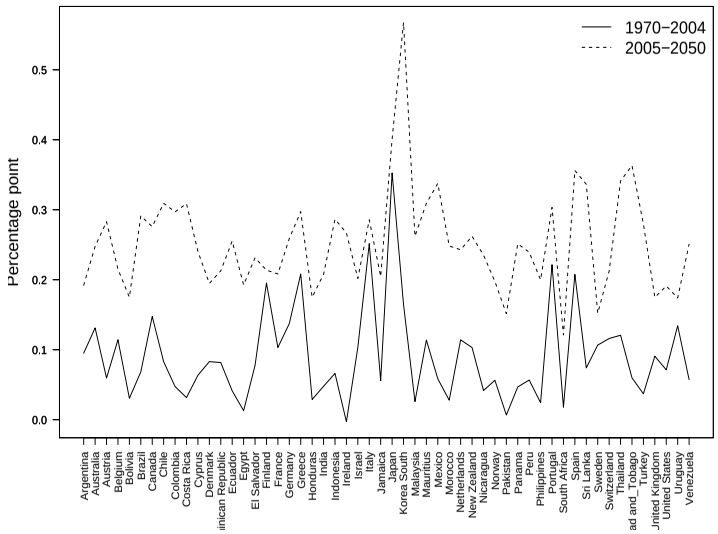
Source: World Development Indicators

Figure 3: Comparison of demographic trends in 1970-2004 and 2005-2050. Source: World Population Prospects: The 2006 Revision

(a) Population growth



(b) Change of share of elderly in total population (age)



(c) Change of share of elderly in the labor force (odep)

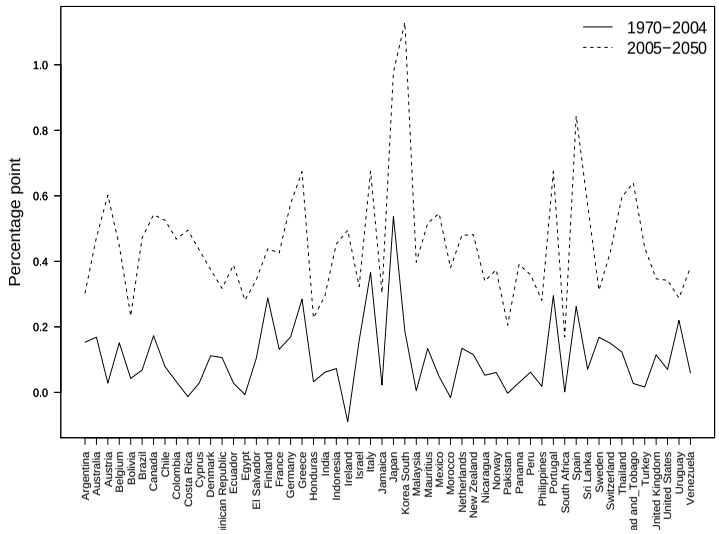
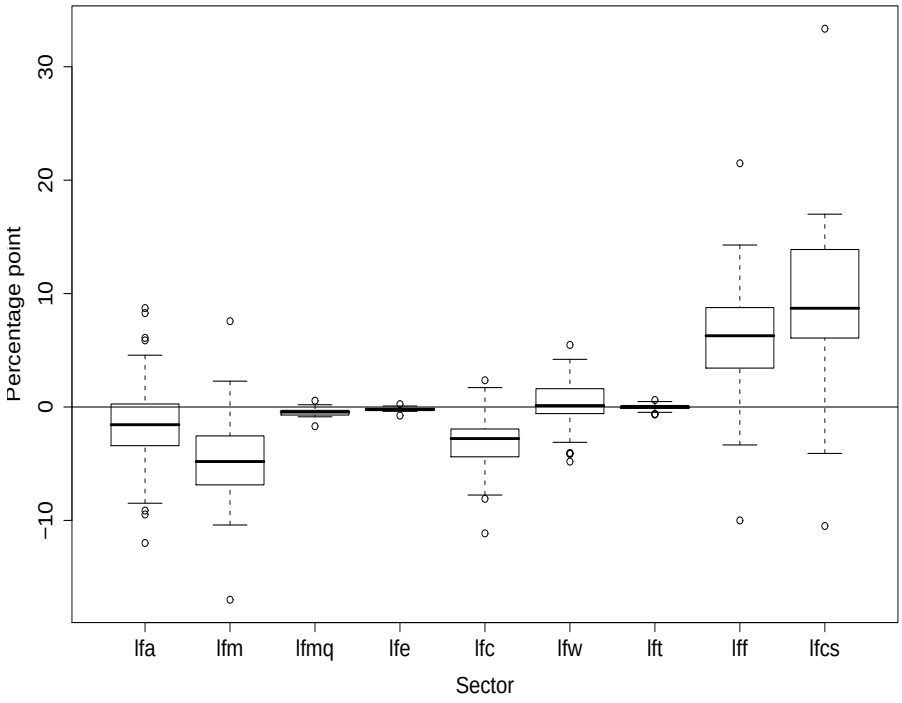
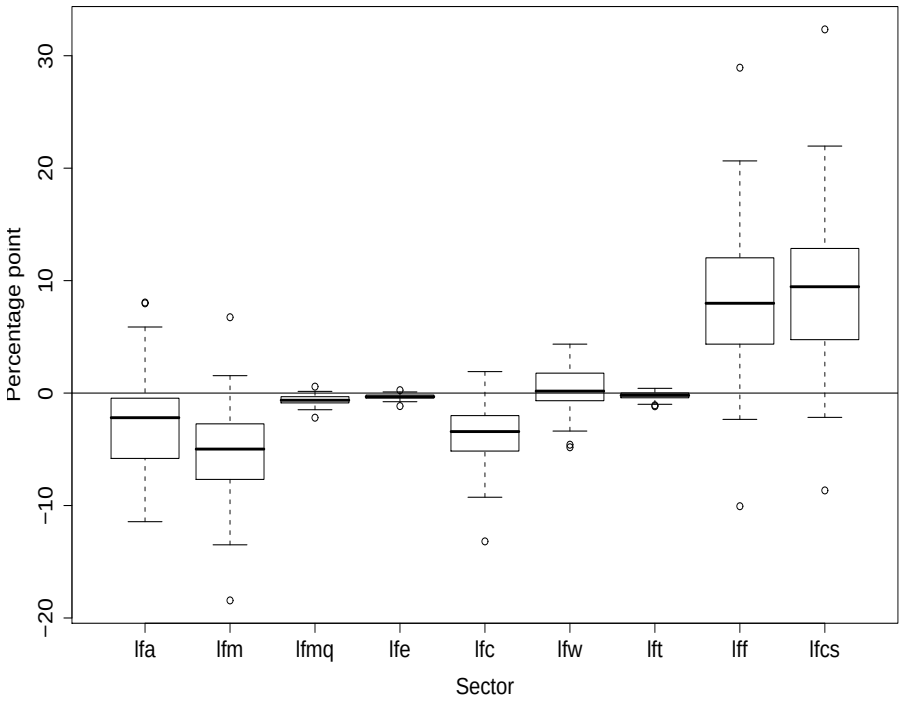


Figure 4: Difference between the base and alternative scenarios (percentage points) 2050

(a) Share of elderly in total population (age) is used as predictor



(b) Share of elderly in the labor force (odep) is used as predictor