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Research Article

Decomposing the change in labour force indicators over time

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Table of Contents

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a research article

Decomposing the change in labour force indicators over time

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Abstract

In this paper we study changes in the size and the composition of the labour force in five selected OECD countries from 1983 through 2000. We apply a recent decomposition method to quantify the components of the change over time in the crude labour force rate and the mean age of the labour force. Our results show that the change in the crude labour force rate was dominated by the change in age-specific labour force participation rates. For the mean age of the labour force we find that for males the change in the age composition of the population predominately explains the overall change while the results for females are less clear-cut.

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1. Introduction

There is a growing literature that investigates the impact of demographic changes on labour force indicators. Besides the compositional effect that works through the age structure this literature is concerned about the direct effect that operates via a change of age specific rates. As Johnson (2002), pp. 113-114, notes ”*...demography is not the only, or even the most important, factor influencing the relative size and structure of the labour force. . . . Furthermore, behavioural factors which determine age- and sex-specific participation rates are more important than the population age structure in determining economy-wide employment shares.*” Changes in age-specific rates may be caused by individual factors as well as institutional and macroeconomic variations which include shifts in the demand as well as supply of labour (e.g., economic swings, delayed labour market entry due to prolonged education, early retirement exits). These micro and macro level determinants may in turn be related to demographic changes as put forward by Easterlin (1978), Easterlin (1987) and more recently by Shimer (2001).

To eliminate the effect of changes in the age distribution that biases labour market indicators, age-adjusted or age-standardised labour market indicators are considered. For instance, in a recent publication Szafran (2002) presents age standardized labour force participation rates from 1960-2000 for the United States of America. Choosing the age distribution of the population in 1960 as the standard, Szafran (2002) shows that the age adjusted labour force participation rates from 1960-2000 are higher compared to the crude rates of labour force participation. As a consequence of increasing population ageing, the differences between the adjusted and unadjusted labour force participation rates are expected to increase for the projected period 2000-2045. The effect of demographic changes on the unemployment rate in the United States of America for the period 1957-1977, is studied in an earlier contribution by Flaim (1979). The demographic developments are found to put upward pressure on the unemployment rate with different results according to the age distribution used to standardize for the changing composition of the labour force.

Standardisation is the classic tool of demographers to eliminate compositional effects from demographic indicators relating to two or more populations or to two or more time points. However, a disadvantage of those methods (whether one uses direct or indirect standardisation) is their dependence on an arbitrary standard. As a consequence, an alternative approach is to decompose the change over time of crude demographic rates into a direct change in the characteristic of interest and the change that is attributable to a change in the structure or composition of the population (e.g. Kitagawa (1955), Das Gupta (1978)). An excellent review of those methods is given in Canudas Romo (2003), chapter 3.

Vaupel (1992) introduced a new decomposition method of the components of the change over time of demographic variables. The method separates the change over time of demographic variables into a direct change in the characteristic of interest and an indirect change that captures the structure or composition of the population. Recently, this method has been applied by Vaupel and Canudas Romo (2002) and Canudas Romo (2003) to study, e.g., the time derivative of averages over age and over subpopulations. An advantage of this method is definitely its simplicity. For instance Canudas Romo (2003), p. 144, states "*the change over time in the crude death rate can be separated into the average change in the death rates and the covariance between the death rates and the age specific growth rates*". Similarly, Canudas Romo (2003), p.144, writes "*the change in the population growth rate of the world is the average change in the countries' population growth and the variance of the growth rates.*" Besides its simplicity the new decomposition method proposed by Vaupel (1992) and Vaupel and Canudas Romo (2002) offers two improvements compared to the standard decomposition method by Kitagawa (1955) (cf. Canudas Romo (2003), p. 134ff). First, the decomposition method by Vaupel (1992) allows for the possibility that the change over time of the variable of interest may be assumed to be exponential, logistic or any other type. In the decomposition method by Kitagawa a linear change is assumed. Secondly, though both methods are equivalent if the implementation assumes a linear change of the variables of interest, the interpretation of the indirect change (or structural component) is more appealing in the decomposition method by Vaupel (1992). In case of the method by Vaupel (1992) the structural component describes the dynamic relationship between the variables in a better way as compared to the compositional component in the method by Kitagawa which simply is the difference of the normalized weights (with the average of the demographic characteristic as weights).

In this paper, we apply the decomposition method of Vaupel and Canudas Romo (2002) to estimate the magnitude of direct (behavioural) and indirect (structural) components of the change of two labour market indicators in five selected OECD countries over the past two decades. In most developed countries the labour force is projected to age and shrink. However, part of the shrinkage of the labour force may be reinforced by the direct effect of decreasing labour force participation rates (in particular among the young, the elderly, and men). On the other hand, the shrinkage of the labour force might be attenuated by increasing participation rates of women. The effect on the mean age of the labour force is less clear cut since lower participation rates of elderly persons have a rejuvenating effect on the labour force while lower participation rates among young people reinforce the ageing of the labour force. To quantify how much of the change in labour market indicators — such as the crude labour force rate and the mean age of the labour force — is due to the fact that the age distribution has shifted towards lower or higher participation cells versus the change in participation rates themselves, we apply the decomposition method of Vaupel and Canudas Romo (2002). By comparing countries with differing labour market institutions we investigate whether the importance of the behavioural versus compositional effect on the change in labour market indicators is also related to specific labour market regulations.

The focus of our paper is therefore on decomposing the change in labour market indicators into compositional changes of the population structure and direct changes of age specific rates. Most studies that discussed changes in labour force participation rates have applied the method of standardization. In contrast to these studies whose prior aim is to control for changes in the population structure our primary focus is on estimating the change in the population structure that caused changes in aggregate labour force indicators. We apply the decomposition method by Vaupel (1992) since it allows for a more flexible assumption on the type of change and a more appealing interpretation of the compositional change.

The paper is arranged as follows. In the next section we review the evolution of the crude labour force rate and the mean age of the labour force over the last two decades in five OECD countries: France, West-Germany, Spain, United Kingdom and US. Section 3 gives first a brief review of the decomposition method developed by Vaupel and Canudas Romo (2002) and compares it to the decomposition method by Kitagawa. In the second part of the same section we present the decomposition of the labour force indicators. The final section concludes.

2. Ageing of the Labour Force

Population ageing currently receives high attention in economics, in particular with respect to its implications for the sustainability of social security systems such as the pension, health and elderly care systems. Above all, the fiscal sustainability of pension systems deserves most attention. It is, in fact, the most important, immediate and visible financial effect of ageing (in particular when pension systems are mandatory, chiefly operated by public sector and based on the pay as you go principle). Rother et al. (2004) estimate for France, West-Germany, Italy, and Spain, the total burden directly and indirectly connected to pension expenditure (if the systems are unchanged) to rise foreseeable close to 90% of GDP from 2000 to 2050.

However, other less direct implications are equally very important. In fact, population ageing also affects the *size* and the *composition* of the current workforce and this will in turn affect the productivity and economic performance of a population (Blanchet (1992), Disney (1996), Johnson (2002), OECD (1998)). Though there is no consensus in the literature on whether an older labour force does indeed depress productivity and competitiveness, a change in the composition of the labour force will certainly have an impact on labour market policies, such as rethinking human capital investment (e.g., life long learning), etc.

In Figure 1 and Figure 2 we consider the time path of two major labour market indicators: the crude labour force rate (defined as the total labour force divided by the population of working age) and the mean age of the labour force. We plot them for five selected OECD countries (France, United Kingdom, West-Germany, Spain, and the US).[5] We have chosen France, United Kingdom, and the US as representatives of populations that age more slowly as compared to the fast-ageing countries West-Germany and Spain.[6,7] These countries are also representative of different social security systems (Economist (2003)).

As regards old age insurance, European countries have a long tradition in state provided pension benefits and the pension system is still for the major part based on public provisions and constructed on the so-called pay-as-you-go principle. France, West-Germany, and Spain have very large mandatory public pension systems while private schemes are little developed: corporate schemes are seldom compulsory and individual scheme are trifling (Rother et al. (2004)). On the contrary, private schemes are important in United Kingdom and especially in US. In US, large parts of pension income are from pension funds by companies (employees). In United Kingdom, the public provisions lost part of their importance in favour of individual private arrangements (savings and insurance contracts) (Economist (2003)). Note: The different sources of income for retirement we mentioned are usually referred to as the First (State), the Second (Corporate) and the Third (Individual) pillar. As is well known (Gruber and Wise (1999)), these alternative pension systems (will) constitute different incentives to continue work at older ages and also provide different pathways to leave the labour force.

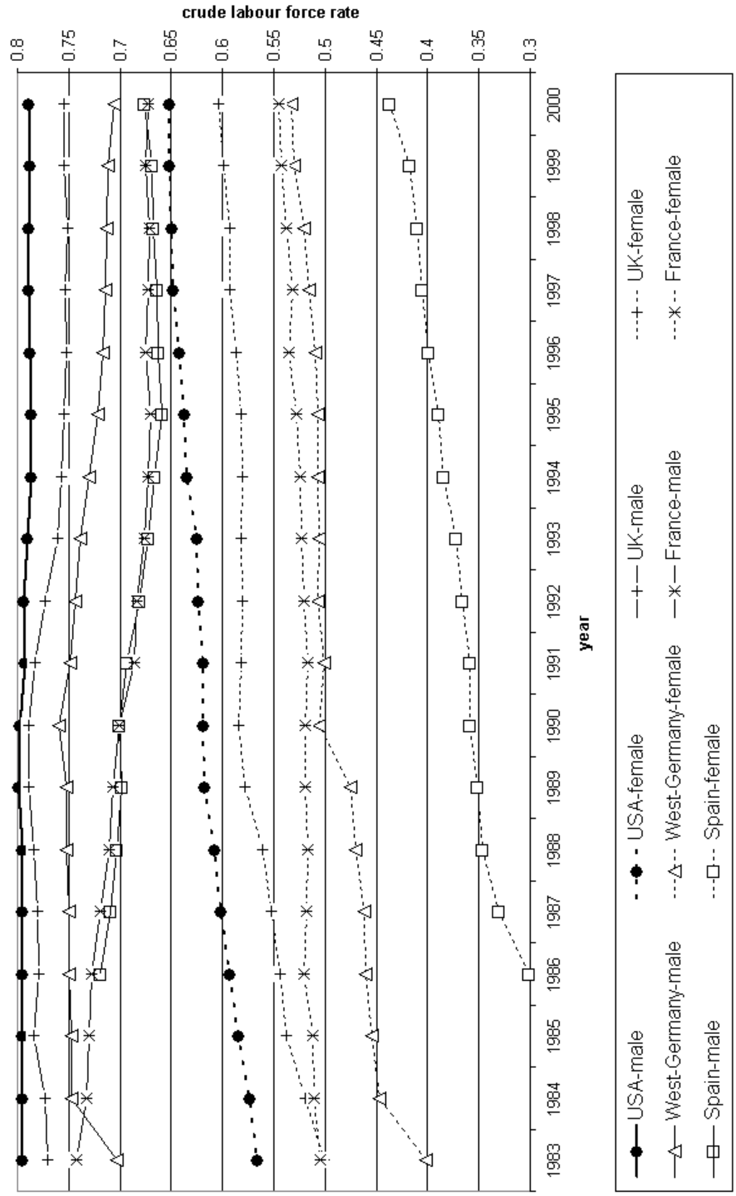
Figure 1 clearly shows the shrinking of the crude labour force rate for males while the crude labour force rate for women has increased during the last two decades. From 1983 to 2000, the highest crude labour force rate for males among the countries studied

[5] All European data used in the paper are from the Eurostat Database 2000 (Eurostat (2000)) and refer to mid-year data (second quarter of the year in most EU countries). Labour force is defined as the sum of employed and unemployed people. The US data are from OECD available online at www.1.oecd.org/scripts/cde/members/LFSDATA. In case of Spain, comparative data are only available starting in 1986.

[6] In Italy the Italian national statistic institute (ISTAT) revised its quarterly Surveys of labour force starting in 1992. Questionnaire, definitions and data processing changed to conform to international standards and to better investigate some specific aspects of the Italian labour market. ISTAT did not provide a revision of data before 1992. Consequently, time series of labour force indicators are not consistent and comparable before and after 1992. For this reason, Italy which was planned to be included in our analysis due to its strong population ageing was left out and Spain favoured to it.

[7] We use data for West-Germany from the old Länder only, i.e., we exclude data from the former GDR after 1990. The reason is that we lack homogeneous data of the two States. Data precision before unification is uncertain for former GDR.

Figure 1: Crude labour force rate by selected OECD countries, 1983-2000.

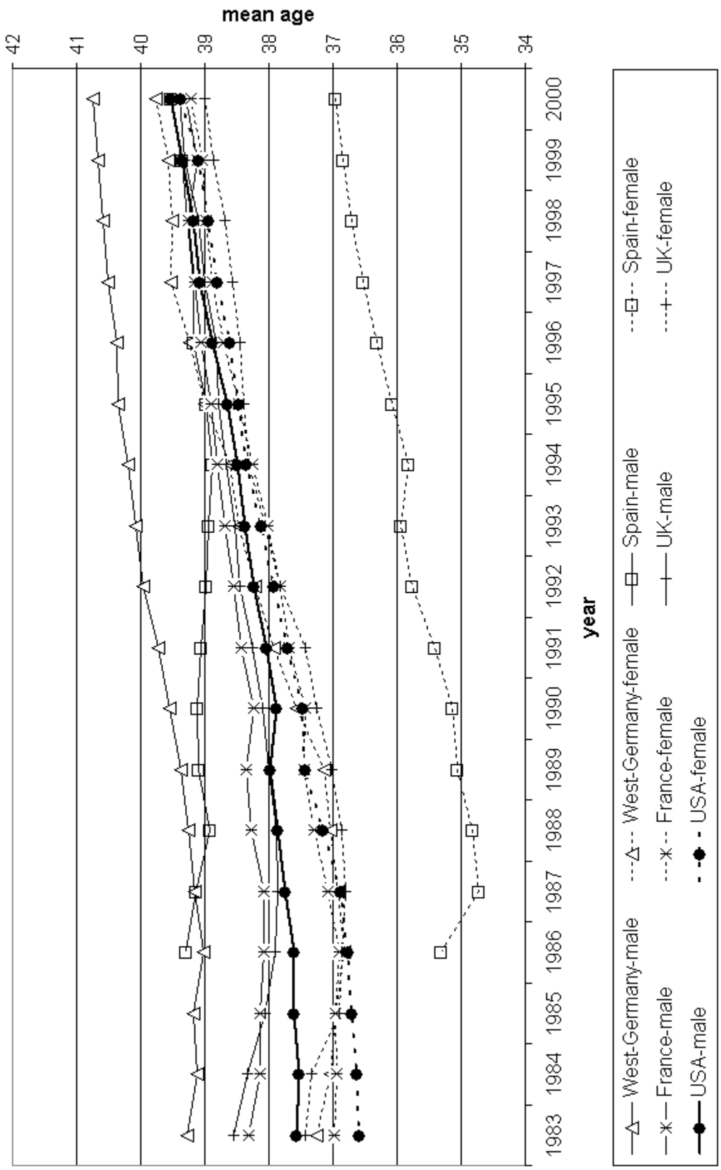


was observed in the US followed by the UK, West-Germany, France, and Spain. While the crude labour force in the US is still close to 80 per cent for males in the late 90s, the value for France and Spain has already declined to 70 per cent during the last two decades. Contrary to the trend in the labour force of males, the crude labour force rate for women increased over the last two decades. Similar to men, the highest labour force participation was observed among females in the US, followed by the UK, France, West-Germany, and Spain. Neither for males nor for females do our data indicate a convergence of crude labour force rates across countries over time. However, as these figures suggest, the trend in the crude labour force rate does not yet indicate that ageing of the population may imply a shortage of labour. In fact, comparing the European and American labour force rates for females indicates that there might still be some potential labour force pool among women that has not yet entered the labour market.

To capture the ageing of the labour force we plot the mean age of the labour force for the same set of countries and time period in Figure 2. During the time period 1983-2000, West-Germany had the oldest labour force for males with the mean age of the labour force increasing from about 39 years in the early 1980s to close to 41 years by the end of the 1990s. The male mean age of the labour force in France, the UK, and Spain has been lower during the whole time period (except for Spain in 1986 and 1987) and approaches the values of the US in the late 1990s. For all countries, the mean age of the female labour force is still below the corresponding figure for males. During the 1990s, a pronounced increase in the mean age of the labour force of females led to a convergence of the male and female ages of the labour force. For the UK, the US, and partly also for France, the gender gap in the age of the labour force almost disappeared in the late 1990s. For West-Germany and Spain, the mean age of the female labour force is still a lot below the corresponding figure for males. Compared to the development of the crude labour force rate, the picture for the age of the labour force indicates that population ageing is clearly having its impact on the composition of the labour force.

Part of the decrease in the crude labour force rate and the increase in the mean age of the labour force over time is caused by a compositional change of the population. I.e., without any change in the labour force participation rate for each age group a rise in the proportion of older workers in the labour force (which have lower participation rates) would, other things being equal, lower the economy-wide crude labour force rate and increase the mean age of the labour force. This is the standard age composition effect commonly controlled for in demographic analysis and generally used to explain the shrinking and ageing of the labour force. However, besides the pure compositional change, certain changes in the age-specific labour force participation rates apply as well. Labour force participation rates have on average decreased at younger and older ages (as caused by later entry into and earlier exit from the labour market) while they have increased at middle ages for females (see Gruber and Wise (1999)).

Figure 2: Mean age of labour force by selected OECD countries, 1983-2000.



To determine how much of the change in the crude labour force rate and the mean age of the labour force reflects a change in age-specific labour force participation rates as compared to a change in the age composition of the population we apply the decomposition method by Vaupel (1992) to both of these labour force indicators in the next section.

3. Decomposing Labour market indicators

3.1 Method

We apply a new decomposition method of the change in an average as introduced by Vaupel and Canudas Romo (2002). We denote $\bar{v}(t)$ as the average of a variable over the characteristic x (e.g., age) at time t:

$$\bar{v}(t) = \frac{\int\limits_0^\infty v(x,t)w(x,t)dx}{\int\limits_0^\infty w(x,t)dx} \tag{1}$$

where $w(x,t)$ denotes a weighting function. The second variable may be any alternative characteristic and need not necessarily coincide with time. Since in this paper we are interested in the change of labour force indicators over time we shall restrict our further analysis to the case where the second variable always denotes time t.

Examples of such indicators are, for instance, the crude labour force rate $\bar{l}(t)$ and the mean age of the labour force $\bar{a}_L(t)$. The *crude labour force rate* is defined as the total labour force divided by the population of working age:

$$\bar{l}(t) = \frac{\int\limits_{\omega_1}^{\omega_2} l(a,t)N(a,t)da}{\int\limits_{\omega_1}^{\omega_2} N(a,t)da} \tag{2}$$

where $l(a,t)$ denotes the fraction of people aged a at time t who participate in the labour force (the labour force participation rate by age), the variable $N(a,t)$ denotes the number of people aged a at time t and ω_1 and ω_2 are the lower and upper age bounds, respectively, of the labour force. The crude labour force rate can be considered as the expected/mean value of the age-specific labour force participation rate $l(a,t)$ with $\frac{N(a,t)}{\int\limits_{\omega_1}^{\omega_2} N(a,t)da}$ being the weighting function.

The *mean age of the labour force* is given by

$$\bar{a}_L(t) = \frac{\int_{\omega_1}^{\omega_2} a\, L(a,t)da}{\int_{\omega_1}^{\omega_2} L(a,t)da} = \frac{\int_{\omega_1}^{\omega_2} a\, l(a,t)N(a,t)da}{\int_{\omega_1}^{\omega_2} l(a,t)N(a,t)da} \tag{3}$$

where $N(a,t)$, $L(a,t)$, and $l(a,t)$ denote the population, labour force and labour force participation rate at age a and time t and ω_1, ω_2 are again the lower and upper age bounds of the labour force. We set $\omega_1 = 15$ and $\omega_2 = 75$ in (2) and (3).[8]

In Vaupel and Canudas Romo (2002) it is proved that the change of the average over time, $\dot{\bar{v}}$, can be decomposed into two components:

$$\dot{\bar{v}} = \bar{\dot{v}} + Cov(v, \acute{w}). \tag{4}$$

In the above equation and in what follows, a dot above a variable indicates the time derivative $\dot{v} = \frac{\partial}{\partial t} v(x,t)$ and the acute is used to express the relative derivative or intensity:

$$\acute{w} = \frac{\frac{\partial}{\partial t} w(x,t)}{w(x,t)} = \frac{\partial}{\partial t} ln\left[w(x,t)\right].$$

The first component on the right hand side of equation (4) is the average change of the function of interest while the second component measures the covariance between the variable of interest and the intensity of the weighting function. In mathematical terms, these expressions are given by

$$\bar{\dot{v}} = \frac{\int_0^\infty \frac{\partial v(x,t)}{dt} w(x,t)dx}{\int_0^\infty w(x,t)dx}$$

and

$$Cov(v, \acute{w}) = \frac{\int_0^\infty [v(x,t) - \bar{v}(t)][\acute{w}(x,t) - \bar{\acute{w}}(t)]w(x,t)dx}{\int_0^\infty w(x,t)dx}.$$

More intuitively: the first term, the average change, accounts for the change observed in the population produced by a direct change in the characteristic of interest. The second term, the covariance term, accounts for the structural or compositional component of change (i.e., the change in population heterogeneity). Similar to Vaupel and

[8] Since we have no information on the distribution of labour force by age for ages above 75 and this might be a very selected group as well, we have chosen to restrict the upper age to 75.

Canudas Romo (2002) we refer to the first term as the direct change or level-1 effect of change and to the second term as the compositional component or level-2 effect of change.

In comparison to the method by Vaupel (1992) the well-known decomposition by Kitagawa (1955) is presented here.[9] It is based on the difference between the average of a variable at two different time points, $\bar{v}(t+h), \bar{v}(t)$. Kitagawa's decomposition is in discrete time and is given by (cf. Canudas Romo (2003), p.18)

$$\bar{v}(t+h) - \bar{v}(t) = \sum_x \left(\frac{\frac{w_x(t+h)}{w_.(t+h)} + \frac{w_x(t)}{w_.(t)}}{2} \right) [v_x(t+h) - v_x(t)]$$
$$+ \sum_x \frac{v_x(t+h) + v_x(t)}{2} \left(\frac{w_x(t+h)}{w_.(t+h)} - \frac{w_x(t)}{w_.(t)} \right)$$

with $w_.(t) = \sum_x w_x(t)$.

As already noted in the introduction, the decomposition by Kitagawa assumes a linear change of the variables of interest while the decomposition method by Vaupel (1992) is not restricted to the linear change. Moreover, the level-2 effect in the decomposition by Vaupel (1992) considers the dynamic relation between the variables of interest while the structural component in the decomposition by Kitagawa is the difference in the normalized weights.

3.2 Application

Crude labour force rate Applying formula (4) to the definition of the crude labour force rate (2) yields the expression for the change in the crude labour force rate over time:

$$\dot{\bar{l}} = \bar{\dot{l}} + Cov_N(l, \acute{N}) = \bar{\dot{l}} + Cov_N(l, r).$$

The subscript N denotes the weighting function while r stands for the age-specific population growth rates. The first term $\bar{\dot{l}}$ captures the direct effect, i.e., the average change in age-specific labour force participation rates. If, for example, the average duration of education increases due to a higher fraction of people obtaining a university degree then the time derivative $\dot{l}$ is negative for the respective age groups (say e.g., $\dot{l}(a,t) < 0\,\forall a \in [18, 25]$). If, on the other hand, the average age of retirement increases, then the time derivative $\dot{l}$ might be positive for the age groups concerned (e.g., $\dot{l}(a,t) > 0\,\forall a \in [55, 65]$). The sign of the average of the time derivative, $\bar{\dot{l}}$, then depends on the intensity

[9] We present here only the basic decomposition method by Kitagawa. For a full review of decomposition methods see Canudas Romo (2003).

of these two changes and also on the sizes of the involved age groups. The second term $Cov_N(l, r)$ is the structural or compositional component of change, it relates to changes in the age composition of the population.

In Table 1 and Table 2, we report the contribution of the direct (level 1) and compositional effects (level 2) to the change in the crude labour force rate between 1985 and 2000 for females and males separately. Similar to Vaupel and Canudas Romo (2002), we study the change in the crude labour force rate and in the mean age of the labour force at the mid-year (1992.5 or 1993.5 respectively). The application of the continuous formula to discrete data is based on the assumption that the change occurred continuously over time (see Appendix for the estimation procedure). In fact between 1985 and 2000 the monotonic increase of the rates approximate a constant rate of change (see Fig.1 and Fig.2). In each table we draw a line which divides the observed from the estimated values. In particular, the lower part first presents the components of the decomposition and then the estimated change which may be compared to the observed change at the midpoint of the time interval in the upper part. [10]

Table 1: Crude labour force rate for females, $\bar{l}$, per thousand, and the decomposition of the change over time from 1985 (1987 for Spain) to 2000 for France, West-Germany, Spain, UK and US.

	France	West-Germany	Spain	UK	US
$\bar{l}(1985)$	512.3	453.9	330.3	537.2	583.9
$\bar{l}(2000)$	545.5	532.7	437.3	603.7	652.0
$\bar{l}(1992.5)^*$	523.4	486.5	372.5	567.2	614.9
$\dot{\bar{l}}(1992.5)^*$	2.2	5.2	8.2	4.4	4.5
$\bar{\dot{l}}$	2.1	5.2	7.7	3.4	3.9
$Cov_N(l, r)$	0.2	0.0	0.5	1.1	0.6
$\dot{\bar{l}} = \bar{\dot{l}} + Cov_N(l, r)$	2.3	5.3	8.2	4.4	4.5

*For Spain the derivative is evaluated at 1993.5.

As evidenced in Table 1, the largest increase in the crude labour force rate (denoted by the variable $\dot{\bar{l}}(1992.5)$) for women took place in Spain followed by West-Germany, the US, the UK, and France. Except for the UK and the US, more than 90% of the change in the female crude labour force rate can be explained by the average in the change of the age-specific labour force participation rates. For the UK and the US, the indirect (age

[10] We chose 1985 as the lower bound to exclude the initial decrease in mean age of the labour force that occurred for most countries between 1983 and 1985 (Figure 2). A similar argument explains why we chose 1987 as the lower bound for Spain.

Table 2: Crude labour force rate for males, $\bar{l}$, per thousand, and the decomposition of the change over time from 1985 (1987 for Spain) to 2000 for France, West-Germany, Spain, UK and US.

	France	West-Germany	Spain	UK	US
$\bar{l}(1985)$	729.7	747.4	709.2	783.9	795.0
$\bar{l}(2000)$	672.6	705.2	676.7	755.2	788.5
$\bar{l}(1992.5)^*$	698.1	726.4	692.2	768.3	791.3
$\dot{\bar{l}}(1992.5)^*$	-3.8	-2.8	-2.5	-1.9	-0.4
$\bar{\dot{l}}$	-3.4	-1.7	-2.9	-2.9	-1.1
$Cov_N(l,r)$	-0.4	-1.1	0.4	1.0	0.6
$\dot{\bar{l}} = \bar{\dot{l}} + Cov_N(l,r)$	-3.8	-2.8	-2.5	-1.9	-0.4

*For Spain the derivative is evaluated at 1993.5.

structure or level 2) effect constitutes about a quarter and one eighth, respectively, of the overall change. For males (Table 2) the biggest decline in the crude labour force rate took place in France, followed by West-Germany, Spain, the UK, and the US. Similar to females, the direct effect of a change in age-specific labour force participation rates dominates. For West-Germany and France, about 60 and 90 per cent, respectively, of the overall change in the crude labour force is captured by changes in the direct effect. For males in the UK, Spain, and the US, the decline in age-specific labour force participation rates exceeds even the total decline in the crude labour force rate and the compositional change becomes positive. In other words, for age groups with high labour force participation we observe a positive growth rate of the corresponding subgroup of the population. This is exactly what a positive covariance term between l and r implies. This kind of information would be lost if we had applied only an age standardization procedure instead of a decomposition analysis over time. We estimate negative compositional effects only for men in France and West Germany. For those countries, we observe therefore negative growth rates of age groups with high labour force participation.

To gain more insight into the contribution of each age group to the total change over time, we apply formula (4) to five-year age groups (see Canudas Romo (2003), chapter 7):

$$\dot{\bar{l}} = [\bar{\dot{l}} + Cov_N(l,r)]_{\omega_1}^{x_1} + [\bar{\dot{l}} + Cov_N(l,r)]_{x_1}^{x_2} + ... + [\bar{\dot{l}} + Cov_N(l,r)]_{x_n}^{\omega_2}. \qquad (5)$$

Note that the covariance term will include the mean of the labour force participation rates and the mean of the age-specific growth rates and therefore is a function of all age groups. The above formula allows to estimate the contribution of the direct and compositional change to the age-specific change in the crude labour force rate.

In Figure 3-7 we plot the age decomposition for female and male changes in the crude labour force from 1985 (1987 in case of Spain) to 2000. The overall picture is a decrease in the crude labour force rate at younger (less than 23 years) and older ages (over 63) for both females and males.[11] Only in case of the US (independent of gender) and females in the UK is the change in the crude labour force rate positive at older ages. As noted earlier, this might be caused by the different pension systems, and hence, retirement disincentives in the US and the UK compared to the other countries included in our study. For age groups in between, the change in the crude labour force rate does not show a uniform pattern for males, and it is also quite small. For males we may therefore conclude that younger and older age groups contribute most to the change in the direct and compositional effect over time. For females at ages 27.5 through 57.5 a pronounced increase in the crude labour force participation rate is apparent, with Spain and West-Germany having experienced the biggest increase. A closer look at female age-specific changes shows that the increase of the labour force participation rate at ages 27.5 through 57.5 (denoted as level 1 effect in Figure 3 to Figure 7) contributed most to the increase in the overall crude labour force. While the local maximum of the direct effect for those age groups is close to the late 40s for France, West-Germany and the US, it is evident that for the UK and Spain the increase in labour force participation rates in the early 30s and early 40s, respectively, was the largest factor. As illustrated in Canudas Romo (2003), the numerous fluctuations in the compositional component through a detailed age composition can be explained by the past and present demographic history within the age-specific growth rates.

Mean age of labour force Application of formula (4) to equation (3) yields the change in the average age of the labour force over time:

$$\begin{aligned} \dot{\bar{a}}_L &= Cov_L(a, \acute{L}) = Cov_L(a, \acute{l} + \acute{N}) \\ &= Cov_L(a, \acute{l}) + Cov_L(a, \acute{N}) = Cov_L(a, \acute{l}) + Cov_L(a, r) \end{aligned} \tag{6}$$

Since $\dot{a} = 0$, there is no level 1 effect and the change in the mean age of the labour force can be explained by a compositional effect alone which equals the change in the labour force size by age. From equation (6) we see that the average age of the labour force will increase if the covariance term is positive which implies that the age-specific

[11] Our data comprise five-year age groups, and we report all components of the decomposition at mid-year of five-year age groups.

Figure 3: Age-specific crude labour force rate for females and males, $\bar{l}$ and the decomposition of the change over time from 1985 to 2000 for France.

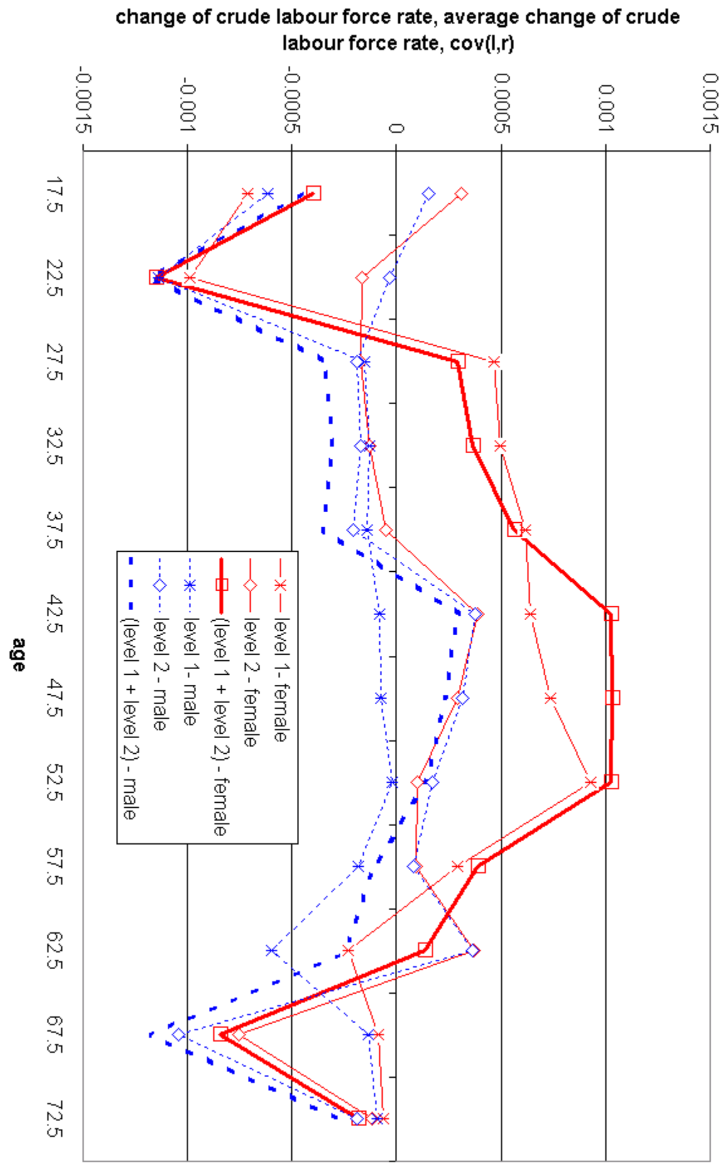


Figure 4: Age-specific crude labour force rate for females and males, $\bar{l}$ and the decomposition of the change over time from 1985 to 2000 for West-Germany.

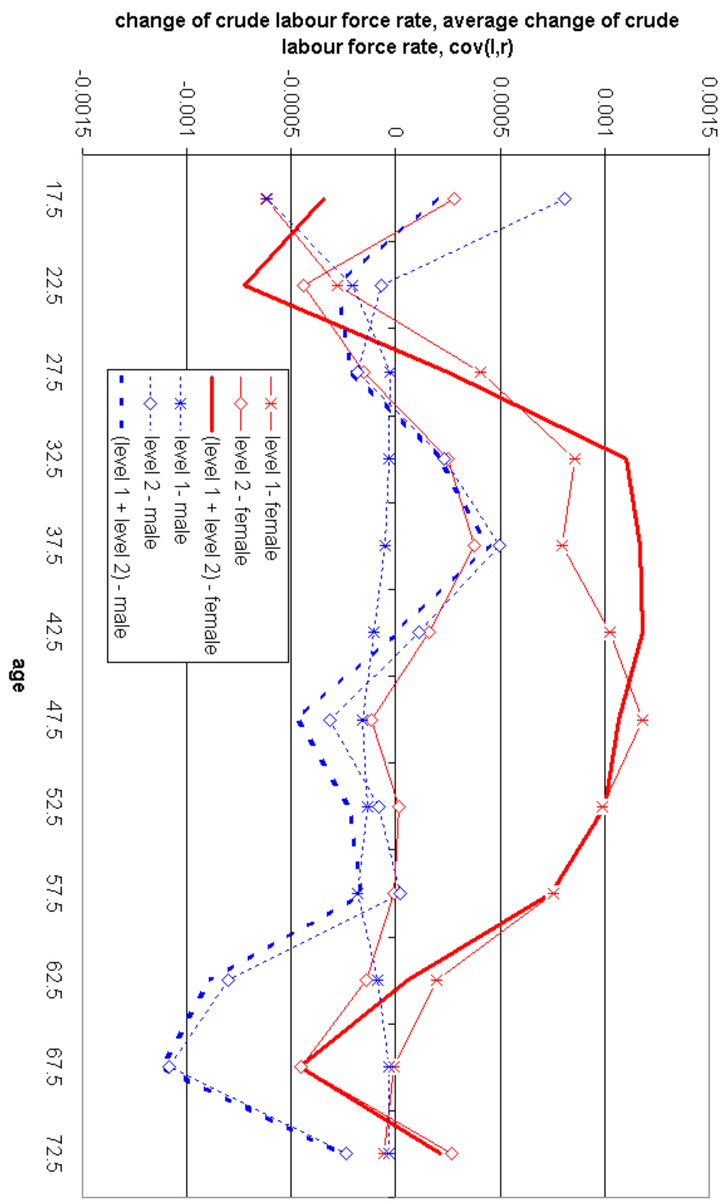


Figure 5: Age-specific crude labour force rate for females and males, $\bar{l}$ and the decomposition of the change over time from 1987 to 2000 for Spain.

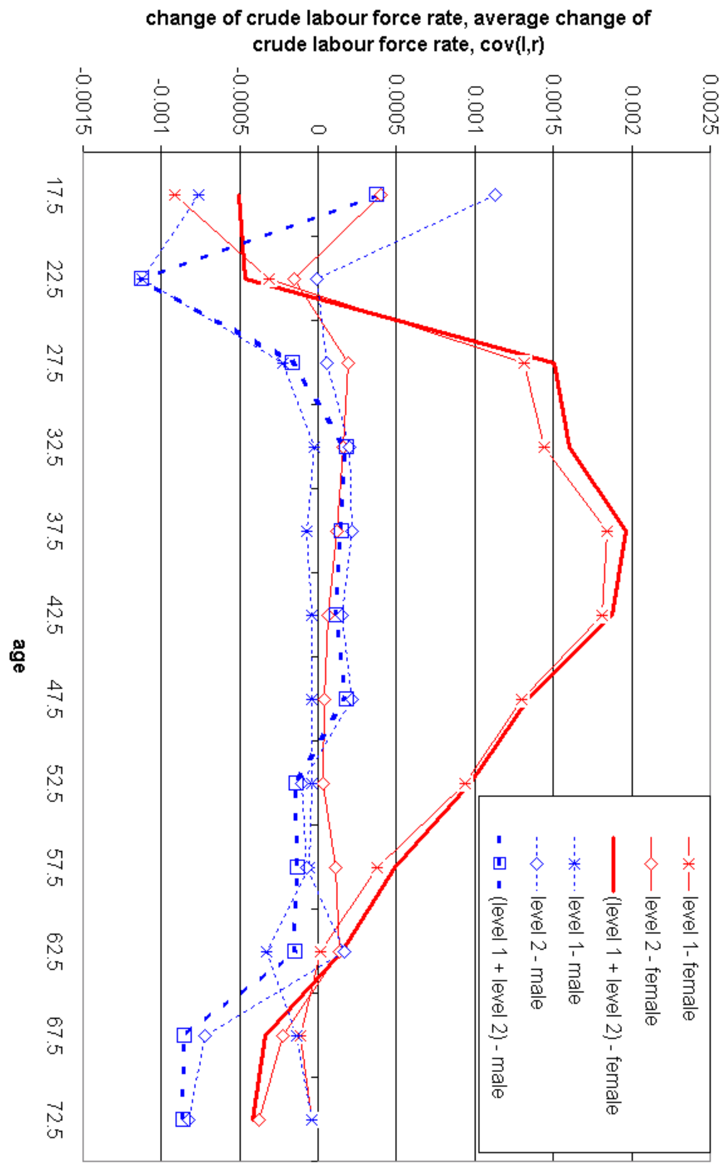


Figure 6: Age-specific crude labour force rate for females and males, $\bar{l}$ and the decomposition of the change over time from 1985 to 2000 for the UK.

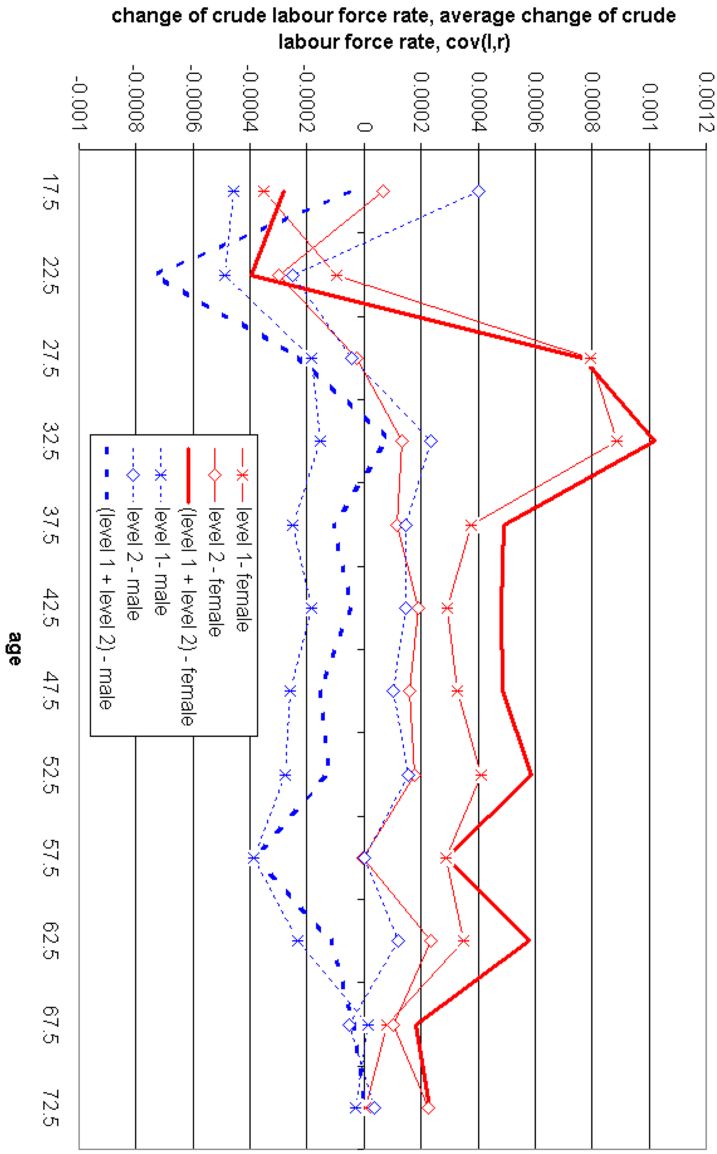
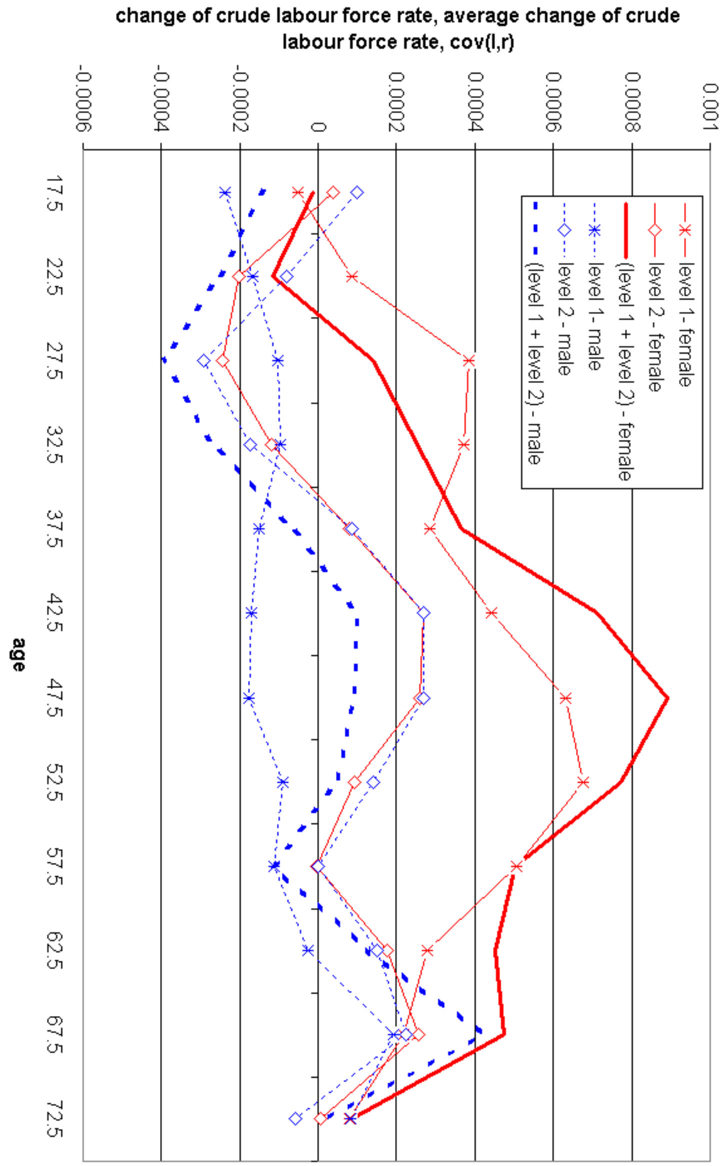


Figure 7: Age-specific crude labour force rate for females and males, $\bar{l}$ and the decomposition of the change over time from 1985 to 2000 for US.



growth rates of the labour force increase with age. The covariance term can be further decomposed into the compositional change of the age-specific labour force participation rate and the compositional change of the age-specific population sizes. Hence, the change in the average age of the labour force is due to a change in the age-specific labour force rates versus a change in the age composition of the population (cf. Vaupel and Canudas Romo (2002), p.6).

Table 3: Mean age of labour force for females, $\bar{a}_L$, and the decomposition of the change over time from 1985 (1987 for Spain) to 2000 for France, West-Germany, Spain, UK and US.

	France	West-Germany	Spain	UK	US
$\bar{a}_L(1985)$	36.95	36.95	34.73	36.90	36.70
$\bar{a}_L(2000)$	39.22	39.76	36.96	39.00	39.38
$\bar{a}_L(1992.5)^*$	38.13	38.54	36.02	38.05	38.04
$\dot{\bar{a}}_L(1992.5)^*$	0.1513	0.1872	0.1713	0.1404	0.1786
$Cov_L(a,\acute{l})$	0.0771	0.1077	0.1431	0.0391	0.0602
$Cov_L(a,r)$	0.0746	0.0796	0.0261	0.1013	0.1194
$\dot{\bar{a}}_L = Cov_L(a,\acute{l}) + Cov_L(a,r)$	0.1517	0.1872	0.1691	0.1404	0.1796

* For Spain the derivative is evaluated at 1993.5.

Table 4: Mean age of labour force for males, $\bar{a}_L$, and the decomposition of the change over time from 1985 (1987 for Spain) to 2000 for France, West-Germany, Spain, UK and US.

	France	West-Germany	Spain	UK	US
$\bar{a}_L(1985)$	38.13	39.17	39.13	38.05	37.62
$\bar{a}_L(2000)$	39.28	40.74	39.53	39.39	39.53
$\bar{a}_L(1992.5)^*$	38.68	40.03	39.37	38.78	38.57
$\dot{\bar{a}}_L(1992.5)^*$	0.0771	0.1047	0.0310	0.0897	0.1276
$Cov_L(a,\acute{l})$	0.0115	0.0109	0.0345	0.0011	0.0147
$Cov_L(a,r)$	0.0665	0.0936	-0.0040	0.0885	0.1134
$\dot{\bar{a}}_L = Cov_L(a,\acute{l}) + Cov_L(a,r)$	0.0780	0.1045	0.0305	0.0896	0.1281

* For Spain the derivative is evaluated at 1993.5.

As indicated in Table 3 and Table 4, the increase in the mean age of the labour force was more pronounced for females than for males. While the change in age-specific labour force rates for women, captured by the term $Cov_L(a,\acute{l})$, accounts for 84 per cent of the overall change in the case of Spain, this contribution declines to 51 and 58 per cent for France and West-Germany, respectively. For the UK and the US, the change in age-specific labour force rates accounts for only 28 and 34 per cent, respectively, of the overall change. For males, the change in the mean age of the labour force can mainly be explained by a changing age composition of the population, except for Spain where the change in the age specific labour force participation rates even dominated the overall change in the mean age of the labour force. More specifically, the change in the age-specific labour force was as low as 1.2 per cent for the UK and around 10 to 15 per cent for France, West-Germany and the US. Though, these figures are much smaller when comparing to the corresponding figures for females, the results nevertheless indicate that the population's ageing is not the only factor that contributes to an ageing labour force. In fact, according to our analysis, in countries with a very generous pension system — such as France, Spain and West-Germany — behavioural changes, such as a change in the labour force participation rate, may cause an even faster ageing of the whole labour force.

4. Conclusions

While most of the literature that investigated the demographic effects on labour market indicators has only applied the method of standardization (cf. Flaim (1979), Szafran (2002)), the aim of the paper was to understand the components of change in labour force participation. We applied a simple and compact decomposition method to two conventional indicators. While the crude labour force indicator measures the quantity of the labour force in relation to the size of the working age population the mean age of the labour force provides an aggregate measure for its age structure. To estimate the components of both indicators over time, across countries and also for different age groups is important in the light of the commonsense argument that ageing populations are faced with a labour force that is ageing as well as shrinking.

Our results have shown that the decrease in the crude labour force rate for males between 1985 and 2000, and also its increase for females in the same period, were dominated by the change in age-specific labour force participation rates as opposed to changes in the age distribution of the total population. For males we have shown that mainly changes in labour force participation rates at younger and older ages explain the change in the crude labour force rate. For females, increases in the labour force participation rates at ages between 25 and 55 years account most for the overall change in the crude labour force rate. Across countries, the decrease in the crude labour force rate for males was most pronounced in France, West-Germany, and Spain, compared to the UK and the US. For females, the increase in the crude labour force was highest in Spain, followed by West-Germany, the US, the UK, and France. Hence, France has experienced one of the most negative labour force developments. Not only did the crude labour force rate among men decline most, but also the increase in the female labour force rate was the lowest.

A decomposition of the change in the mean age of the labour force shows different results for females and males. For females, the increase in the mean age of the labour force is predominantly explained by a change in the age-specific labour force rates in the cases of France, West-Germany, and Spain. For the US and the UK, the main explanation is a change in the age composition of the population. For males, the increase in the mean age of the labour force can mainly be attributed to a change in the age composition of the population, except for Spain, where the change in the age-specific labour force participation rates even dominated the overall change in the mean age of the labour force. An obvious explanation of these results is the fact that male labour force participation rates declined at younger and older ages. While the former effect, ceteris paribus, increases the age of the labour force, the latter decreases it. Consequently, the average effect on the age of the labour force is negligible.[12]

Our results also demonstrate the importance of considering a set of alternative labour market indicators, e.g., crude labour force as well as the mean age of the labour force, if we conduct cross-country comparisons. From the fact that changes in the mean age of the male labour force are more sensitive to compositional changes of the population structure one should not conclude that direct changes (in the labour force participation rates) are irrelevant at all. They may be relevant if we consider the size of the labour force rather than its age structure.

Decomposing the change in labour force indicators is particularly important if we consider a comparison across countries. Let us assume that in two countries we observe an equal increase in the mean age of the labour force. However, the underlying mechanism may be very different. In the first country it could be explained by a decrease in the labour force participation rate at younger ages and a simultaneous increase in labour force participation rates at higher ages without much of a change in the composition of the labour force. In the second country the phenomenon could be attributable to the age composition alone without any change in the age-specific labour force participation rate. Obviously, the implications for the two economies would be very different.

In summary, we argue that for cross-national comparisons of changes in labour market indicators it is important to understand the components of such changes and to present alternative indicators for comparison. The method of decomposing an overall change into direct and compositional effects, as presented in this paper, helps to quantify the causes that explain shrinking versus ageing of the labour force. Both developments are associated with the ageing of the population. Though our study only refers to past changes in labour market indicators and cannot assess the future impact of population ageing on the labour

[12] It should be recalled that the covariance terms in equation (6) are averages over the ages of the labour force.

market, our results indicate that there is some scope for attenuating labour force ageing and labour force shrinkage through policy interventions that aim to change labour force participation rates. Of course, for countries where labour force participation rates for women and men are already high the margin for those behavioural changes are smaller than for countries that still face low female and male participation rates.

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Appendix

Since the decomposition formula applies to continuous changes over time and we have data for discrete time points only we need to estimate the derivative of functions that are only known at discrete time points. We proceed as summarised in the Appendix in Vaupel and Canudas Romo (2002) assuming that the rate of change is more or less constant over the time interval.

Given that we have only data for time point y and $y + h$ we estimate the relative derivative of the function $v(x, t)$ at midpoint $y + h/2$:

$$\acute{v}(x, y + h/2) \approx \frac{\ln[\frac{v(x,y+h)}{v(x,y)}]}{h}. \quad (7)$$

We estimate the value of the function at the midpoint by

$$v(x, y + h/2) \approx [v(x, y)v(x, y + h)]^{1/2}. \quad (8)$$

The derivative of the function is estimated by

$$\dot{v}(x, y + h/2) = \acute{v}(x, y + h/2)v(x, y + h/2). \quad (9)$$