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Demographic change and economic growth[1]

I would like to thank the Oesterreichische Nationalbank for inviting me to review how demographic change has affected economic growth and what impact it might have in the future.

Let me start with a simple cross-sectional plot (chart 1). It shows the annual average growth rate of GDP per capita versus the average annual growth rate of population for the time period 1960–2010. This raises questions about the connections between demographic change and economic growth and the quantitative importance of these relations. As we can see in chart 1, the correlation between GDP per capita growth rates and population growth rates is negligible at low population growth rates and turns negative for higher population growth rates.

Chart 1

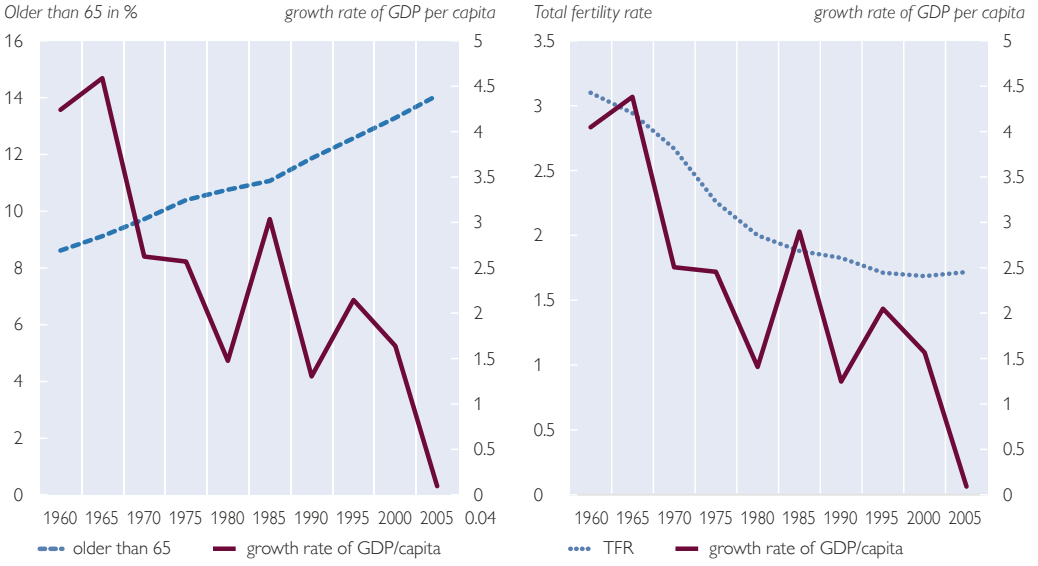
GDP per capita growth versus population growth, 1960–2010

Source: World Bank (2015).

Chart 2 shows the trend of demographic developments in OECD countries over time (1960–2005). The marked increase in the share of people above age 65 (chart 2, left picture) and the declining fertility rate (chart 2, right picture) document the ongoing ageing of the population in these countries. This pronounced ageing process is caused by continuous improvements in

Chart 2

GDP per capita growth, share of elderly from 1960 to 2005



Source: World Bank (2013).

Note: Left picture: Fraction of the population above the age of 65 (in %; dashed line) and the growth rate of per capita GDP (solid line); right picture: TFR and the growth rate of per capita GDP (solid line); the sample represents an aggregate over all OECD countries from 1960 to 2010, where the data is averaged over five years to reduce the influence of business cycle fluctations.

[1] *I am grateful to Klaus Prettner and Sylvia Trnka for proofreading.*

mortality at higher ages and a marked drop in fertility in the 1970s, followed by a stabilisation at low levels of fertility during the past four decades. In the OECD countries, these developments were accompanied by a decrease in the GDP growth rates over the same time period.

However, the stylised facts presented in chart 1 and 2 neither permit us to deduce causalities between demographic and economic developments nor do they help us to grasp the mechanisms that may cause demographic and economic change. We need to analyse how economists have tried to model and understand potential links between these variables.

1 Demographic change and economic growth: a historical review[2]

According to Thomas R. Malthus, there is a strong link between population growth and economic growth. He was the first to endogenously define population growth as being dependent on the state of the economy. As labour grows exponentially and resources only have an arithmetic growth rate, his argument was obviously quite pessimistic in terms of economic growth. As demonstrated in Steinmann's work (1986), such a Malthusian society will ultimately always converge to a low level of output per capita at which the population is in its stationary long-run steady state. The only chance for the economy to converge to a higher standard of living are preventive measures such as restricting marriage behaviour and thereby reducing fertility or positive checks such as famines or other exogenous natural catastrophes. Most importantly, the driving force of the Malthusian model is the negative effect of population growth on output per capita caused by decreasing returns to scale in the factors that can be accumulated.

Besides labour, the neoclassical growth models of the 1960s included physical capital as the second factor of production that can be accumulated. However, these models abandoned the assumption of endogenous population growth and introduced the rate of population growth as an exogenous factor. Similar to Malthus' arguments, their understanding of the relation between economic growth and population growth was pessimistic. In the neoclassical growth models, rising population growth leads to capital dilution thereby reducing output growth in the medium run and leading to a lower output level in the long run. Based on these theoretical arguments, fertility control was seen as a key population policy to foster economic growth. The theoretical framework of the neoclassical growth models could, however, not be verified in econometric studies conducted in the 1960s and 1970s. Various analyses based on cross-country data found an insignificant effect of population growth on economic growth.

In the 1990s, the neoclassical models were extended by directly accounting for human capital as an additional important factor of production. In this context, variations in savings rates and population growth could better explain income differences across countries (Mankiw et al., 1992). Moreover, demographic variables were included in convergence models (Barro, 1991, 1997). The premise underlying these models is based on the neoclassical growth theory in which countries converge to their long-run steady-state equilibrium level of output per worker.

[2] *For a more detailed survey see Prskawetz and Lindh (2007).*

The growth rate of output per worker is modelled to be proportional to the gap between the logarithm of the current level of output per worker and the long-run level of output per worker. While the growth rate is constant, the steady-state equilibrium level of output per worker is assumed to be country- and time-specific and therefore modelled as a linear function of time- and country-specific characteristics. Relying on more sophisticated data and methodologies (panel data econometrics) and disentangling the components of population growth (fertility and mortality), it was possible to identify the link between demography and economic growth in these models. While fertility, population growth and mortality were shown to negatively affect per capita economic growth, population size and its density were shown to be positively related to per capita output growth.

Until the late 1990s, the economic-demographic correlations were modelled at the aggregate level. Thereafter, a new chapter started by modelling the relationship between demographic change and economic growth. Several economists (most prominently Bloom and Williamson, 1998; Bloom et al., 2001; Kelley and Schmidt, 2005) argued that demographic change is important for economic growth if we take into account the change in the population's age structure, i.e. if we abandon the assumption of a stable age distribution. The theoretical foundations can be found in the life cycle models of savings and investment (Modigliani and Brumberg, 1954) and the fact that labour productivity changes by age. While the growth rate of the working age population was shown to have a positive and significant effect on the growth of GDP per capita, the growth rate of the total population was shown to have a negative and significant effect, as clearly stated by Bloom et al. (2011):

> *"... based on the fact that people's economic needs and contributions vary over the various stages of life ... key drivers of economic growth such as aggregate labor supply, productivity, consumption, savings will tend to vary depending on where most people fall in the life cycle."*

2 Age structure changes and economic growth

To understand how the age structure may influence economic growth let us refer to a simple organising framework as summarised in Kelley and Schmidt (2005), where $y=Y/N$ denotes output per capita with Y representing output and N the total population, $z=Y/L$ denotes output per worker with L being the work force and $l=L/N$ denotes the ratio of workers to the total population. The growth rate[3] of output per capita $\hat{y}$ can be decomposed into two terms: the growth rate of output per worker $\hat{z}$ (termed the productivity effect) and the growth rate of the ratio of workers

[3] *A hat on top of a variable indicates the growth rate.*

to the total population $\hat{l}$ (termed the accounting effect).

$$\hat{y}=\hat{z}+\hat{l}$$

This decomposition nicely illustrates that demographic change will definitely influence the accounting effect which can be decomposed further into the difference between the growth rate of the working age population and the growth rate of the total population: $\hat{l}=\hat{L}-\hat{N}$. If the growth rate of the working age population exceeds the growth rate of the total population (i.e. the demographic dividend), the accounting effect makes a positive contribution to economic growth. If the growth rate of the population exceeds the growth rate of the working population, the term $\hat{l}$ becomes negative and the accounting effect acts as a demographic burden.

In addition to the accounting effect, a change in the demographic structure will also affect the growth rate of output per worker, which is often called (labour) productivity or behavioural effect. It has been found that the growth rate of the working age population not only determines the accounting effect but also has a positive effect on the growth rate of output per worker. Among the various demographic variables introduced, the youth dependency ratio turned out to be significantly negatively related to output per worker in most of the studies.

Bloom and Williamson (1998) investigated the role of age structure changes for economic growth in Asia during the demographic transition. Rising youth dependency ratios and the fact that the population grew faster than the working age population led to a demographic burden until the mid-1960s, while a demographic dividend with declining youth dependency ratios and growth rates of the working age population exceeding the growth rates of the total population have been observed since the 1970s. The authors conclude that *"The demographic dividend … in East Asia … accounts for as much as one third of its economic growth."*

For Europe, Kelley and Schmidt (2005) found that the accounting effect was exhausted in the 1970s while the decline in the youth dependency had a strong positive effect on the growth rate of output per worker during the 1970s and 1980s. Among other explanatory variables, Kelley and Schmidt (2005) noted that human capital (as measured by life expectancy and education) induced strong growth whereas financial and political components had more ambiguous impacts. Overall, Kelley and Schmidt (2005) concluded that demographic variables account for 24% of the variability in the growth rate of output per capita for Europe over the time span 1960–1995. Similar results were obtained in the study by Bloom and Williamson (1998) who showed that population dynamics explain almost 20% of the growth observed in Europe over the time period 1965–1990.

As proposed by Bloom and Williamson (1998), demography may influence economic growth through savings and investment. Moreover, educational enrolment and human capital

were emphasised as a third channel through which demography may affect economic growth (Bloom and Canning, 2001). Most importantly, these authors also found a significant effect of the interaction between demographic variables and policies. The role of institutions and policies was also emphasised by Bloom et al. (2003) who showed that open economies, a flexible labour force and modern institutions ensure that a country can actually reap the demographic dividend:

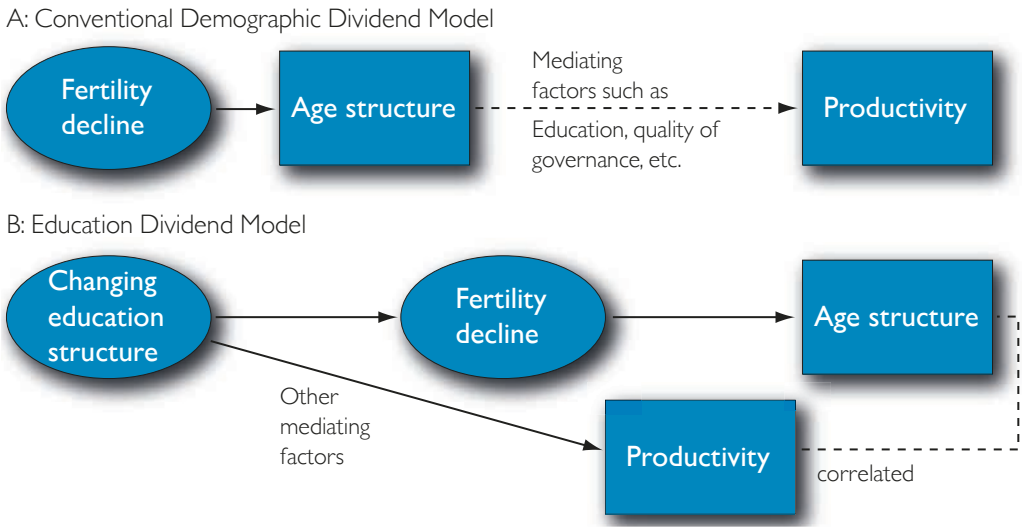
> *"… Demographic dividend (window of opportunity) will depend on critical policy areas like public health, family planning, education, economic policies that promote labour-market flexibility, openness to trade and savings …Policy makers must then plan for future health care and pension-income needs of this baby-boom generation when it ages."*

Other authors (e.g. Feyer, 2007) take into account the internal demographic composition of the workforce and use a sample of OECD countries from 1960 to 1990 to document that the share of workers aged 40 to 49 is positively related to output. Similarly, Prskawetz and Lindh (2007) present growth regressions for a sample of the EU-15 Member States from 1950 to 2005 which show that the share of the working age group 50–64 contributes positively to economic growth, while a large share of old and young population has a negative effect on economic growth.

Cuaresma et al. (2013) challenged the mechanism of the demographic dividend arguing that it might have been an educational dividend. As presented in chart 3 (upper panel), the conventional demographic dividend model argues that the fertility decline initiates a change in the age structure by first inducing a decrease in the youth dependency ratio and subsequently an increase in the growth rate of the working age population as compared to the overall population. Education plays a role in so far as it acts as a mediating factor that is conducive to the role of age structure effects for productivity.

Chart 3

Conventional demographic dividend versus education-triggered dividend model



Source: Lutz (2014).

In contrast, in the education-triggered dividend model (chart 3, lower panel), the changing educational structure is the key driver that initiates the demographic transition and is also positively related to productivity.

With the help of IIASA's human capital database (Lutz et al., 2007) that includes all age-specific educational structures back to the 1970s, Lutz et al. (2008) have shown how important it is to consider the interaction of age and education in economic growth models.

Based on a simple growth regression for a panel of 101 countries over the time period 1970–2000, they were able to demonstrate that secondary education is the most important level of education that determines the productivity of developing countries. The indirect effects that influence economic growth through technology can also be linked to specific age groups and educational levels. The results indicate that technology is positively related to secondary education of older age groups (possibly reflecting the imitation process) and to tertiary education of younger age groups (possibly reflecting the innovation mechanism).

Overall, our analysis of growth regressions that include changing age structures indicates that Europe experienced a demographic dividend in the 1970s and that age structures were also favourable for the productivity process. Whether projected future changes in the demographic structure may induce a burden on economic growth is difficult to answer because this will, among other things, depend on whether and how institutions will adapt to demographic changes. To understand the challenge of demographic change, let us briefly review the demographic development.

3 Demographic change in Europe

In the past decades, demographic change differed considerably in Europe. Chart 4 plots the development of the total fertility rate (TFR) in selected European regions throughout the period 1960–2008. While the overall trend of a decline in the TFR was quite similar across European regions, the timing and extent of the fertility reductions varied. In Northern European and German-speaking countries the fertility decline started during the mid-1960s and decreased to a level around 2 in the early 1970s. In the Southern European countries the drop in fertility was delayed by almost 10 years and reached the level of 2 in the early 1980s. While fertility in German-speaking and Southern European countries continued to drop well below the replacement level of about 2 and stabilised at a value close to 1.4 in the last decade, fertility in Northern European countries stabilised at higher values (around 2), i.e. the replacement level of fertility.

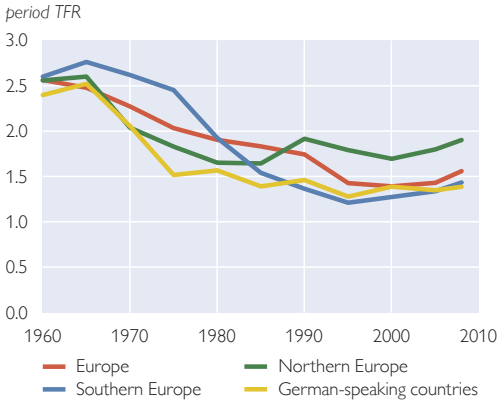
As past fertility developments will have a pronounced effect on population ageing, the challenge of demographic change will be quite different across European regions. In a recent study, Reher (2015) documented the relation between the baby boom and baby bust and its effect on population ageing for several developed countries. The study

showed that in countries with a strong baby boom the baby bust was actually relatively weak. These countries will experience a strong increase in the share of elderly in the period 2010–2050 (e.g. Australia, Canada, Czech Republic, Iceland, New Zealand, etc.). In countries that had a weak baby boom, the baby bust was strong. These countries will experience a strong decrease in the labour force between 2010–2050 (e.g. Bulgaria, Germany, Italy, Poland, Slovenia, etc.). While it will be predominantly the increasing share of the elderly who will exert pressure on the social welfare system, it will be mainly the declining labour force that will reduce output and also decrease the tax base. Hence, the impact on the expected economic effects will depend on whether the baby boom or the baby bust is the dominant historical development.

Parallel to the fertility drop in Europe, gains in life expectancy were very pronounced. While the average life expectancy at birth in the EU was 66.9 (72.3) years for males (females) in 1960, it rose to 76.1 (82.2) years for males (females) in 2012. However, differences in mortality across Europe are striking. In 2013, the lowest and highest levels of life expectancy for males (females) reached 68.7 (78.0) in Lithuania (Bulgaria) and 80.1 (85.2) in Sweden (Estonia). Mortality is also quite different across socio-economic groups within countries: e.g. in Austria, at age 35 the remaining life expectancy for males (females) having only primary school was 41.86 (48.08) and for those having a university degree 48.86 (50.81) in the years 2011/12. Increasing survival to older ages will shape the future of European populations and account for population ageing. However, the fact that gains in life expectancy have been paralleled by gains in healthy life expectancy constitute a great potential and opportunity for societies. Nevertheless, the pronounced diversity in mortality differentials across Europe and across socio-economic groups needs to be addressed.

Chart 4

Period TFR in selected European regions, 1960–2008



Source: Bongaarts and Sobotka (2012).

4 Quantifying economic dependency

Demographic structures are usually summarised by demographic dependency ratios that relate children and the elderly (assumed to be those below age 20 and above age 64) to the active population between age 20 and 64. If we suppose that children and the elderly are dependent and the active population contributes to the economic output, these ratios acquire an economic interpretation. However, such measures are severely flawed if used to represent economic dependency. Not everyone assigned to the dependent population is actually dependent and not everyone who is part of the active population is actually employed. In a recent study (Loichinger et al., 2014), we proposed several alternative economic dependency ratios.

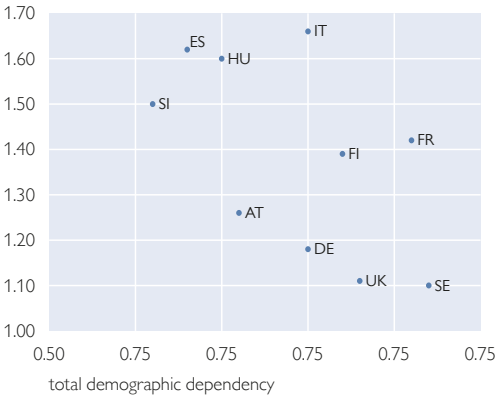
In one indicator, i.e. employment-based dependency, we related non-

working to working persons based on the following definition: we classified children, unemployed, housewives/men, retirees and other inactive persons as non-working population and counted only those as working who actually worked full-time, part-time or did compulsory military or alternative civilian service. Chart 5 illustrates such an employment-based dependency ratio for a set of European countries in 2011 versus the standard demographic dependency ratio. The rather scattered points indicate that countries with a similar demographic dependency ratio (e.g. Italy and Germany) may be very different when we measure dependency by employment status.

To take into account the degree of dependency within the dependent population and the degree of economic ability of those who support others, we also introduced an economic dependency ratio. It is based on the age-specific characteristics of consumption and income elaborated in our work on National Transfer Accounts (Sambt and Prskawetz, 2011). We called the difference between age-specific average consumption and income "life cycle deficit" and alternatively "life cycle surplus" in case the life cycle deficit is negative. We then defined the NTA-based economic dependency ratio by relating the life cycle deficit of the young and elderly to the life cycle surplus of adults. A comparison with the employment-based dependency ratio indicated no obvious correlation. Countries like Sweden and the UK or Slovenia and Italy have similar employment ratios but differ in their economic dependency once we take into account the degree of dependency.

Chart 5

Employment-based and demographic dependency ratios in 2011



Source: Loichinger et al. (2014).

To summarise, when defining the role of demographic structure for economic output we should neither use fixed age limits nor age alone.[4] Not age per se but the economic activity that characterises people will, in the end, determine the economic consequences of demographic change.

5 The challenge of individual and population ageing for economic growth

When viewed at the individual level, the ageing process is quite heterogeneous and varies by educational attainment, work history, family forms, etc. In line with the economic theory of the life cycle model, we expect that a longer healthy life span will affect microeconomic decisions such as education, employment, savings, investment and retirement. However, such behavioural effects may not be supported by prevailing labour market institutions, family and retirement policies, etc. Bloom et al. (2007), for instance, find that the positive effect of increased longevity on

[4] *In a recent paper, Cuaresma et al. (2014) have shown that prospective age measures, i.e. measuring ageing by taking into account remaining life expectancy instead of a fixed chronological age, have better explanatory power in the long run.*

aggregate savings disappears in countries with pay-as-you-go pension systems and high replacement rates. Moreover, norms and values, as well as the current economic situation, may also have an impact on behavioural effects. Indeed, as also argued by Bloom et al. (2011), not the demographic change but rigid policies and institutions are the main problem of population ageing.

At the aggregate level, changes in the age structure will influence the compensation of labour as well as physical and human capital. Substitution among production factors and the economic structure of a country will determine the specific economic consequence of population ageing. How resources will be redistributed across generations will also depend on the respective social security system (including health care, pensions, long-term care insurance).

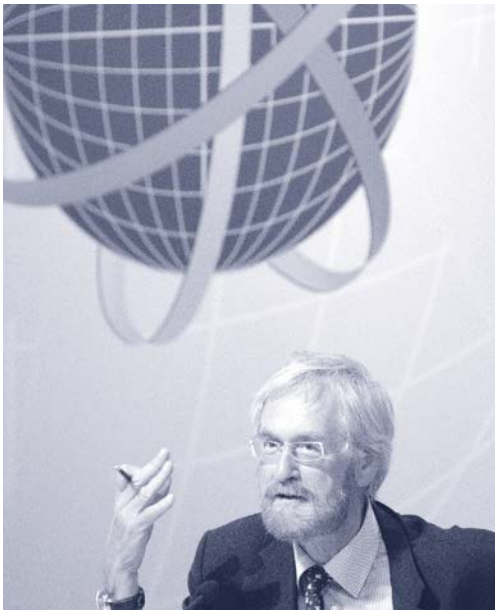
In their papers, Nagarajan et al. (2013a, 2013b) offer an in-depth bibliometric analysis of the impact of population ageing on economic growth and discuss the main channels. They identify three main mechanisms: (1) consumption and saving patterns, (2) public expenditure and (3) human capital. About 70% of all empirical studies that focus on the role of public social expenditure in ageing societies as the main mechanism envisage a negative impact of ageing on economic growth. Arguments in favour of a negative relation include the fact that, in ageing populations, tax revenues will decline as the working age population shrinks, while the demand for health and pension expenditures will increase. In contrast, 60% of all empirical studies that focus on human capital as the key mechanism fail to find a negative relation between population ageing and economic growth. However, there are also the arguments that expenditures for social security benefits may compete with expenditures for education or that an older work force is less productive. It should be noted that these claims failed to be verified in many empirical studies (cf. Prskawetz and Lindh, 2006 and, more recently, Göbel and Zwick, (2012) for a review on age and productivity). The positive relation between population ageing and economic growth is also more relevant for consumption and savings patterns.

According to Prettner (2013), an increase in longevity implies that individuals save more. In standard endogenous growth models, this means that more resources are available for R&D, which, in turn, drives technological progress and thereby productivity growth. For semi-endogenous growth models (where the long-run per capita output growth rate is positively related to population growth), Prettner (2013)

has shown that the relative change of fertility compared to mortality ultimately determines which role population ageing plays in economic growth. Prettner and Timborn (2012) demonstrated that even if the negative effect of low fertility on the flow of labour into the R&D sector dominates in the long run, the positive impact of longevity on savings during the transition overcompensates the negative effect in

the short run. Such stylised facts are consistent with the negative relation between fertility and economic growth observed in many developed countries during the second part of the 20th century. However, continued low fertility and increasing survival to older ages may jeopardise these positive effects in the long run. These studies are in line with literature that investigates the role of longevity on purposeful R&D investment (Hashimoto and Tabata, 2013; Strulik et al., 2013; see also Prettner and Prskawetz, 2010 for a review of the impact of demographic change on economic growth in modern R&D-based economic growth models).

Nagarajan et al. (2013a, 2013b) conclude that we should be cautious when



investigating the relation between population ageing and economic growth. They summarise their findings as follows:

> *"... the impact of ageing on economic growth does not depend on the mechanisms analysed but rather varies according to the empirical methodology used."*

In general, more sophisticated econometric methods such as GMM estimations or simulations such as CGE models yield less negative results. For instance, allowing for endogenous human capital accumulation in CGE models reduces welfare losses of ageing populations.

Most importantly, since ageing is a new phenomenon, we cannot draw on our experience. To quantify the role of population ageing for future economic growth we should not only rely on past econometric studies but also use more complex simulation models that help us understand how population ageing may impact economic growth for alternative future scenarios of behavioural and institutional changes. We need to take into account general equilibrium effects of demographic change on rates of return to labour and capital in a global world where population ageing takes place at different speeds. As illustrated by Krueger and Ludwig (2007), the distribution of wealth and welfare will also be affected. The expected increase in wages and decrease in interest rates might benefit young people with lower levels of assets, while older, asset-rich people might lose in terms of welfare.

To conclude, I would like to emphasise how important it is to "demystify popular fallacies" (Börsch-Supan, 2013) in the economics of ageing. Among the seven myths discussed by Börsch-Supan, let me highlight the fact that ageing is not about the old. We know from various studies that the process of ageing is shaped at young ages. Investments in education and health are prerequisites for successful ageing not only at the individual level but also for societies at large. Investment in skills and education is also stressed in the European Commission's report that discusses the link between demographic change and economic growth (Fotakis and Peschner, 2015):

"Europe and the rest of the developed world …. will need to promote, more so than the developing world, knowledge-intensive, high value added economic activities that generate genuine productivity growth, based on innovation, capital deepening, better organization and greater investment in education and skills for higher-quality workforce."

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