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Evidence Review

Demographic Ageing and Productivity

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About PIN

The Productivity Insights Network was established in January 2018 and is funded by the Economic and Social Research Council. As a multi-disciplinary network of social science researchers engaged with public, private, and third sector partners, our aim is to change the tone of the productivity debate in theory and practice. It is led by the University of Sheffield, with co-investigators at Cambridge Econometrics, Cardiff University, Durham University, Glasgow Caledonian University, SQW, University of Cambridge, University of Essex, University of Glasgow, University of Leeds and the University of Strathclyde. The support of the funder is acknowledged. The views expressed in this report are those of the authors and do not necessarily represent those of the funders.

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Introduction

All countries are experiencing the process of population ageing – increasing proportion of older age groups in the age structure of the population. Many developed countries will have a declining working age population and most will have a falling proportion of people of working age in the total population. A common solution to this relative decline in the potential labour force is faster improvements in labour productivity due to fast technological change. This note looks at the interplay between demographic change and productivity to evaluate if expectations of faster productivity growth are justified.

The relationship between productivity, age and demographic change has attracted the attention of social sciences for centuries. Since Malthus it has been recognised that economic growth and demographic change are closely related. However the relationships between these two processes are not straightforward and successive generations of social scientists continue to study them.

I will first review the existing evidence about the interaction between the aggregate productivity and population ageing at a macro level. Later I will turn to our knowledge of interactions between age and productivity at an individual level.

Macro Level

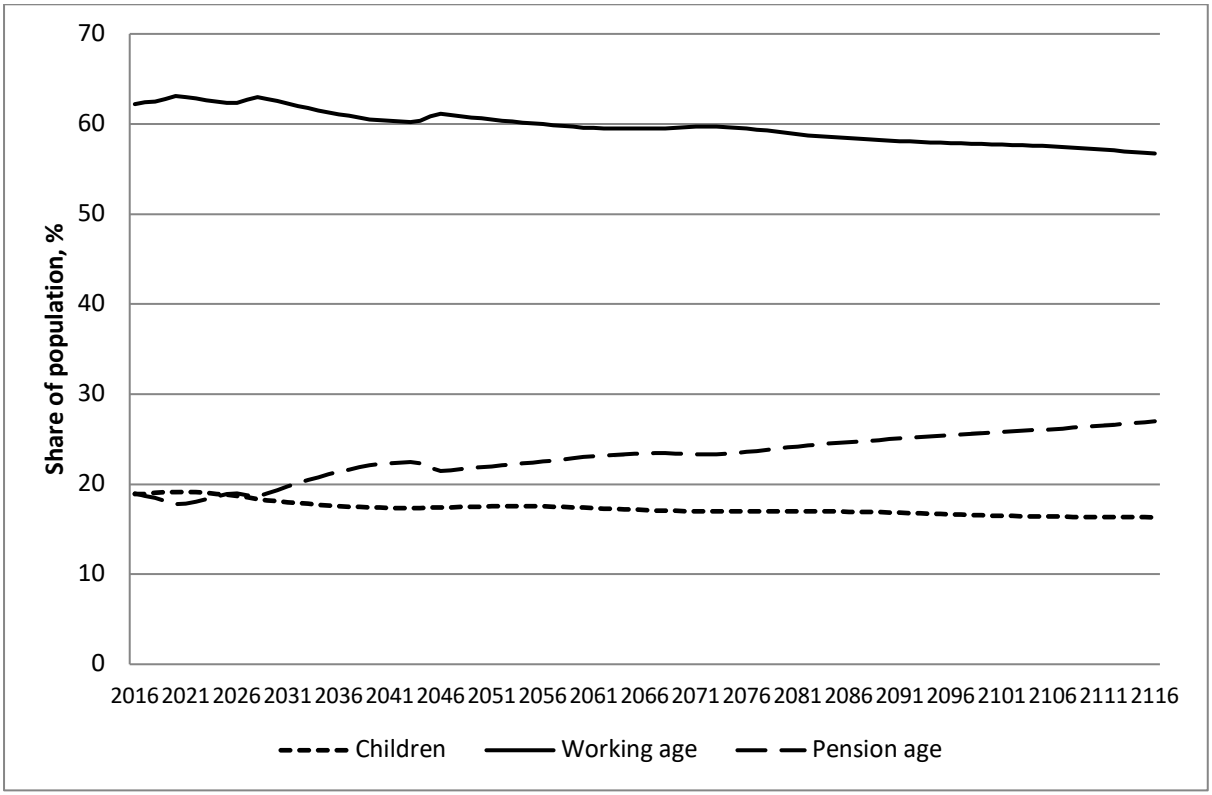
There are several channels through which population age structure can affect the economic growth: 1) effect on the relative size of the labour force, 2) effect on aggregate savings rate and thus capital accumulation, 3) effect on TFP growth, 4) effect on sectoral composition, 5) potential externalities and finally 6) changes in individual productivity associated with age, seniority and experience (which is discussed in the next sections). I will look at each channel individually.

Relative Size of the Labour Force

Developed countries have mostly completed the process of demographic transition from rural societies with high fertility and mortality to urban societies with low fertility and high longevity. During the early stages of demographic transition the countries experience what Ronald Lee and Andrew Mason call the first demographic dividend (e.g., Mason and Lee, 2006). It is associated with a declining share of dependants in the total population and lasts around 5 decades. But by now developed countries have entered the period when the share of working age population is declining and the first demographic dividend turns negative.

Over the next several decades the UK population will experience a decline in the proportion of the working age population (see Figure 1). The UK is not unique in this and similar trends are observed in most other countries.

Figure 1. Projected age structure of the UK population over the next 100 years



Source: 2016-based ONS population projections, Principal scenario

According to the Principal scenario of the 2016-based ONS population projections, the share of working age population in the UK will decrease from 62% in 2016 to 57% to 2116.[1] It is also important to remember that the working age group not only gets relatively smaller but also gets progressively older as time passes.

Obviously the demographic trends become progressively uncertain over such a long time horizon, however, the trend to declining working age population has been very persistent and few doubt that it will continue into the future. Working age population is a strong predictor of the economically active population. Another factor that determines the size of the labour force is age-specific labour force participation rates. According to the OECD data participation rates for people aged 55-65 has increased from 53% in 2000 to 66% in 2016 and for people aged 65+ from 5% to 11%. This of course is not only the result of longer and healthier lives but also of changes in state pension age.

Subject to the uncertainty necessarily inherent to demographic projections, our understanding of the effects of population ageing on the size and structure of the UK population and working age population is relatively good. The biggest uncertainty lies within the migration trends, which can change fast and have a strong and immediate impact on the population structure. For example, Lisenkova and Sanchez-Martinez (2016) looked at the effect of declining migration due to Brexit and its long-term effects on the economic performance. They found that due to a lower labour force and its changing composition by 2065 GDP would be 9% lower and GDP per person almost 1% lower than without a Brexit induced fall in migration.

[1] These projections take into account the planned increases in the state pension age.

Savings and Capital Accumulation

The life-cycle hypothesis (LCH) describes people's saving and consumption patterns over their life time. According to this during their working life, people work and accumulate assets and in retirement spend these assets. If people behave according to LCH then national savings rate should be higher in countries with a higher proportion of prime working age population and lower in countries with an older population.

Macro-economic data suggest that savings rates decline as the proportion of elderly people in an economy rises. Weil (1994) tests this on data from fourteen OECD countries between 1960 and 1985. His results suggest that a shift of 1% of the population from working age (20-64) to elderly (65+) reduces the private savings rate (net of public savings) by between 0.5 and 0.9 percentage points of GDP. However, his study also shows that demographic structure alone explains only 11% of cross-country variation in savings rates.

Microeconomic data also broadly supports LCH but many studies fail to observe negative savings in old age. Borsch-Supan and Brugiavini (2001) estimate household savings rates by age for six different countries (UK, Netherlands, Italy, Germany, USA and Japan). While the pattern varies somewhat from country to country, savings rates appear to be highest around age 50. But after this point, they do not fall significantly, and do not appear to be negative in any country.

One problem with microeconomic studies of saving behaviour is that they often fail to take into account accumulation and use of pension funds. At least in the case of the UK, where private pensions represent significant portion of pension income, this creates distortions to both saving and dissaving behaviour.

It is possible that the weak link between the demographic structure(s) and savings at a micro level can be explained by the fact that savings is only one mechanism of reallocation of resource across the life time. The other two being public transfers and private transfers (bequests and inter vivos transfers) (McCarthy et al, 2015).

TFP Productivity Growth

There is research that links the rate of technological progress to the age structure of the population. It is assumed that contribution of different age cohorts to the processes of innovation and invention is different. If young and/or middle-aged workers are more inventive/innovative then labour force ageing could have a negative effect on the pace of technological progress that we usually measure as TFP growth. Feyrer (2008) shows that US innovators' median age is stable around 48 over the 1975–95 sample period whereas the median age of managers who adopt new ideas is lower at around 40. Aksoy et al (2016) show that demographic structure affects innovation, with middle-aged workers (40-49) having a strong positive impact on patent applications and older workers (50-59) having a strong negative impact on patent applications. They conclude that population ageing may result in lower rates of innovation. Jones (2010) also finds that innovation is positively affected by young and middle-aged cohorts and negatively affected by older cohorts.

There are several contributions to the empirical growth literature which use demographic variables to explain differences in growth between the countries. They usually regress log output per worker on a number of country-specific characteristics including demographic variables. This approach also allows to decompose output into the contribution for physical capital, human capital and TFP growth.

Feyrer (2007) using this approach analyses 87 developed and developing countries over the period from 1960 to 1990. His major finding is an inversely U-shaped relationship between

changes in the age structure of the labour force and the growth rate of TFP which peaks for workers aged 40–49. He also finds that TFP in the most important channel for the effect of labour force structure on growth.

Aiyar et al (2016) use a similar approach to analyse panel data covering 27 EU countries over 1950 to 2014. They find that an increase in the proportion of workers aged 55-64 is associated with an economically and statistically significant reduction in the growth rate of labour productivity. The decomposition of the aggregate effect into the contribution of factor accumulation and TFP growth confirms Feyrer's (2007) findings that most of the adverse effects of aging come from its negative impact on TFP growth. Their estimates show that the aging of the workforce in the EU has lowered TFP growth by about 0.1 percentage points each year over the past two decades (1984-2007). Our estimates suggest that workforce aging could significantly retard TFP growth over the medium to long term. On the basis of demographic projections from the OECD, the aging of the workforce in the euro area could lower TFP growth by about 0.2 percentage points each year between 2014 and 2035.

The results for the UK show that TFP growth was 0.1 pp per year lower on average between 1984 and 2007 due to labour force ageing. They forecast that over the next two decades (2014-2035) labour force ageing will decrease TFP growth by about 0.5pp per year. According to their analysis the UK is in a relatively good position, as some other EU countries will lose as much as 0.5% of TFP growth due to demographic factors.

Sectoral Composition of the Economy

There is less research in this area but the arguments are very intuitive. Age specific consumption of various goods and services is different. For example, young people consume a lot of education and older people consume a lot of heath care and long-term care and less goods compared with the working age population. As population becomes progressively older this will influence the sectoral composition of demand and as a consequence, will also influence supply. The shift will be from consumer products towards services, especially labour intensive services like house-keeping, health and leisure services. It is also expected that the service sector will continue growing relative to manufacturing due to population ageing. Siliverstovs et al. (2011) "*find that an increase in aging exerts a statistically significant adverse effect on the employment shares in agriculture, manufacturing, construction, and mining and quarrying industries. At the same time, an increasing share of the elderly (decreasing share of the youth) in society positively affects employment shares in community, social, and personal services as well as in the financial sector*."

It is long recognised that it is harder to achieve big improvements in productivity in labour intensive services. ONS produces an experimental series of sector specific TFP productivity in the UK (Table 1). Education, Health and Social work, Art and entertainment and Financial services had the largest negative TFP growth between 1971 and 2007 between -1.13% and -1.19% per year.

Table 1. Average TFP growth, 1971-2007

Sector groups	Average TFP growth, %
Agriculture; Forestry & fishing; Mining & quarrying; Utilities	0.31
Manufacturing	1.74
Construction	-0.56
Wholesale & retail trade; Accommodation & food services	-0.50
Transportation & Storage	2.37
Information & communication	1.40
Financial & insurance activities	-1.13
Real estate activities; Professional & scientific activities; Administrative & support activities	0.53
Education; Health & social work	-1.15
Arts & entertainment; Other services	-1.19
Total Market Sector	0.57

Source: ONS

Venn (2008) provides a taxonomy of economic sectors distinguished by their exposure to workforce aging risks: occupations and professions in which productivity increases (on average) with age, occupations that are age neutral, and occupations in which productivity declines with age. Aiyar et al (2016) calculated that in EU 28 labour force is concentrated in occupations where productivity decreases with age (around 45%), with only around 25% of the work force in occupations where productivity increases with age (the rest is age neutral occupations).

Micro Level

Workers' productivity is determined by individual characteristics and by the characteristics of the company. Of individual characteristics the most important are physical ability (strength, dexterity, and endurance), cognitive ability (memory, special orientation, inductive reasoning, vocabulary size, etc.), education and experience. All of the individual characteristics depend on age. There is a large body of research in psychology and medicine that show that physical and cognitive abilities start declining at a relatively young age. Most cognitive abilities reach maximum level in the 20s and early 30s (Avolio and Waldman, 1994) and decline considerably by the age of 50 (Verhaegen and Salthouse, 1997).

At the same time education and experience increase with age (in the case of education not in a cross-section) and can help overcome negative effects of declining abilities. In addition, the match between the worker's abilities and the type of work that s/he performs can improve with age.

The relative importance of abilities and experience is different in different professions and at different periods of time. There are several papers proposing a categorisation of professions according to whether age increases or decreases productivity (e.g., Warr, 1994; Venn, 2008). Among professions where productivity increases with age are, for example lawyers, professors, managers and medical doctors. Workers with basic jobs, especially jobs that require physical exertion such as factory workers or workers in the construction sector, are likely to become less productive as they age.

Education and training can also help to slow or even reverse the decline in productivity with age. However, fewer training opportunities are offered to older workers, because the beneficial effects of training can be used for a shorter period.

Faster speed of technological change and constant re-training that it requires can, on the one hand put older workers at a disadvantage because of their deteriorating learning capacities. But at the same time age should play a smaller role in the decision to invest in new skills if they need to be updated frequently.

Identifying the relationship between age and productivity at an individual level is difficult for a number of reasons. Börsch-Supan and Weiss (2016) identify three fundamental problems: measurement, selectivity/endogeneity and aggregation.

Some aspects of productivity are easy to measure and they are usually connected with physical performance. And it is well documented that physical ability starts declining at a relatively young age. Other aspects of productivity, such as experience, leadership and managerial skills, knowledge of human nature usually improve with age but they are much harder to measure.

Employment is endogenous to productivity because companies choose to keep the most productive workers. This selection bias potentially gets stronger for older workers, who might choose early retirement and other ways of leaving the labour force if their productivity is low. This process would tend to overstate the productivity of older workers. More productive companies grow faster and hire more new workers who tend to be younger. This might overstate the productivity of younger workers.

Productivity is difficult to measure at the level of the individual, since it is a group phenomenon. This group of workers usually consist of workers of different ages and identifying contribution of individual worker is not that easy, especially since members of the team influence each other's productivity. Older more experienced workers spend some time teaching and supervising younger workers, but this would depress their productivity.

For these reasons microeconometric studies are struggling to paint a consistent picture about the relationship between age and productivity. There are broadly four types of microeconometric studies of relationships between productivity and age:

1. Studies using supervisor's ratings to evaluate employee's performance.
   These studies are often criticised for potential bias of subjective measures. McEvoy and Cascio (1989) review 96 studies on the impact of the employee's age on supervisors' assessment and sales records and find no clear effect of age on productivity.
   There is one data set in the UK which contains information on both workplaces and their employees and also HR managers' assessment of productivity. Workplace Employment Relations Survey (WERS) – a nationally representative survey of British workplaces and their employees. It has been undertaken 6 times: 1980, 1984, 1990, 1998, 2004 and 2011. Stokes et al (2017) in their report to DWP use the two most recent waves (2004 and 2011) of WERS. In chapter 5 they use workplace Human Resources (HR) manager's subjective assessment of their workplace labour productivity and relate it to workforce age composition. They find no significant associations between changes in the proportion of older workers employed and changes in workplace productivity. But they find some evidence that both a higher percentage of older employees, and a higher percentage of younger employees, result in a reduction in labour productivity. The authors say that this is the first study for Britain of the effects of age composition of the workforce and workplace performance.

2. Studies that employ direct measures of productivity. These usually relate to selected professions where output is relatively easy to measure and attribute to an individual worker. They usually concentrate on measuring the productivity of manual work (factory

workers, mail sorters), or highly intellectual individual work (scientific publications, Nobel prizes, court cases). Studies of researchers, innovators and artists by age tend to suggest that productivity peaks in the thirties and forties (Lehman, 1953; Cole, 1979; Simonton, 1988; Miller, 1999; Kanazawa, 2003; Oster & Hamermesh, 1998). Nobel Prize Laureates do their most important contributions in their thirties, according to Jones (2010). The onset of the most innovate age phase increased by about 6 years over the 20th century (which he suggests could be due to a longer training period as the knowledge base has expanded).

These studies can measure the productivity precisely but are only applicable to a limited number of professions and cannot help with generalised conclusions about average performance.

One interesting study which also falls into this category but is concerned with average performance is by Börsch-Supan and Weiss (2016). They use data from a Mercedes-Benz truck assembly plant. At this plant, trucks are assembled by work teams on an assembly line. As a measure of productivity they use the number and severity of production errors that each team has in the process of assembly (because the speed of assembly line is the same for every team). They exploit the daily variation in the team composition of work teams over four years to identify the age-productivity profiles. Team based approach is unusual in the literature – usually productivity is measure at a plant level or individual level. According to the authors this approach allows them to "take into account the individual workers' contribution to their co-workers' productivity". The estimated age-productivity profiles do not show a decline in productivity between 25 and 65 years of age. On the individual workers' level, their average productivity measure actually increases monotonically up to the age of 65.

3. Studies using wages as a proxy for productivity.

   One large exercise looking at age-earnings profiles across time and across countries is done within National Transfer Accounts (NTA) project – the project looks at disaggregating key macroeconomic variables by age. Below is the chart of labour income by age in the UK in 2010. According to this chart labour income peaks for men around 41 and for women around 46. This inverted u-shape pattern is repeated across different time periods and countries although the precise age of maximum earnings moves around, but usually falls into the 40-49 age group.

   However, these profiles do not take into account other factors that change with age especially in a cross-section – the main one is educational attainment of various cohorts.

Figure 2. Labour income by age in the UK, 2010

Source: AGENTA

More sophisticated econometric studies which specifically try to identify a link between age and productivity and control for other important factors find that earnings usually increase with age.

It is often said that wages do not reflect true productivity, especially for older workers. It is argued that pay can increase with age due to seniority. Also they are subject to a selection bias, because more productive workers are likely to stay in the labour force longer because of both their choice and companies' preferences. Lazear (1979) proposed a theory of deferred compensation, which assumes that workers and firms want to be engaged in long-term relationships and therefore increasing earnings might not reflect increased productivity.

Early studies provided evidence that earnings might increase with age for reasons other than productivity and therefore there is a discrepancy between earnings and productivity, particularly at older ages (e.g., Lazear and Moore, 1984).

Boot (1995) and Johnson (2003) use the UK data from 18 th and early 19th century, when labour protection was weak, to show that age-earnings profiles reach a peak in the thirties and that stay stable or decline afterwards.

4. Studies relating plant level productivity to the age of the plants' employees.

   These studies use matched employer-employee datasets which contain information on both firm and employee's characteristics. Early studies were using cross-sections datasets and were finding hump shaped age-productivity profiles (Mahlberg et al., 2009; Prskawetz et al., 2007).

   However more recent studies using dynamic panel data and two-stage regression methods (e.g., Aubert and Crépon, 2006; Dostie, 2011; Göbel and Zwick, 2009, Malmberg et al., 2008) show that the age–productivity relation is sensitive to the estimation method and indicate that controlling for unobserved time-invariant firm heterogeneity and endogeneity leads to a flattening of the age–productivity profile at higher ages.

   Matched data sets are also used to compare age-earnings profiles and age-productivity profiles. Recent studies find little evidence of systematic difference between the two (Aubert and Crépon (2006; Van Ours and Stoeldraijer, 2011). Cardoso et al. (2011) finds that the contribution of older workers to productivity is larger than their earnings.

   There is a long list of references to such studies in Börsch-Supan and Weiss (2016), Skirbekk (2004, 2008), Mahlberg et al (2013) covering the US, Canada, Israel and many European countries. But surprisingly I did not find similar studies using the UK data. The closest I found was the report to the Low Pay Commission by Dickerson and McIntosh (2012). They look at relationships between productivity, earnings and age but concentrate on the young age groups. They use Annual Business Inquiry/Annual Business Survey (ABS) to arrive at firm level productivity and match it at the level of industry with individual worker data from the Annual Survey of Hours and Earnings (ASHE) and the Labour Force Survey (LFS). They find a hump-shaped relationship between age and earning, but fail to find any relationship between age and productivity (age group coefficients are not significant).

   As was mentioned above WERS contains information on both workplaces and their employees but as far as I know it was used only once to look at older workers' productivity.

Conclusions

Macroeconometric studies tend to find a negative association between the share of the older population and growth. The largest contribution to this comes from the negative effect on TFP.

The most rigorous microeconometrics studies with generalizable results use linked employer employee data sets. The current golden standard is dynamic panel data sets. Earlier studies tended to find hump-shaped age productivity profiles. Advances in econometric techniques and improved data sources result in a flattening of the profiles, many studies do not find a negative effect of age on productivity at all.

Thus, there is an apparent mismatch between microeconometric and macroeconometric evidence. One possible explanation of this is externalities, i.e. difference between social and private returns. In the same way as we often discuss positive externalities from human capital (in the form of education) it is possible that demographic trends exert negative externalities in the labour market (Feyrer, 2007).

It is difficult, if at all possible, to discuss the link between productivity and age in isolation. The productivity of the ageing population will be influenced by the skills and health of older workers. A multidimensional analysis would be more useful than addressing issues in isolation.

I have identified several areas where further research in the UK would be useful:

1. There is a surprising gap in the literature using UK micro-level datasets with no studies using linked employer-employee surveys. This suggests that there is possibly a lack of suitable data, although studies using linked employer-employee data sets for other purposes. For example, Haskel et al (2005) study the link between human capital and plant productivity.

2. Various macroeconomic effects identified in the literature could be combined in the macro model with demographic details (e.g., overlapping generations CGE model) to make projections about the future productivity of the labour force.

3. Macroeconomic effects could also be used to look at the regional distribution of potential productivity risks associated with population ageing. In general, spatial differentiation of demographic change attracted relatively little attention but will have significant consequences for regional policy (McCann, 2017).

4. There is no research on potential externalities from population ageing. It would be an interesting study to try to reconcile the macro and micro evidence.

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