TOWARDS A LONGEVITY DIVIDEND: LIFE EXPECTANCY AND PRODUCTIVITY ACROSS DEVELOPED COUNTRIES

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Content

About this report

This report is part of a series of short ILC publications exploring the relation between demographic forces and macroeconomic outcomes. In this paper, the author explores the effects of life expectancy on productivity across developed countries since the 1970s. For this, we utilise the demographic and macroeconomic data collected by the OECD for 35 countries. Productivity is measured in terms of GDP per hour worked, per worker and per person (per capita).

1 minute summary

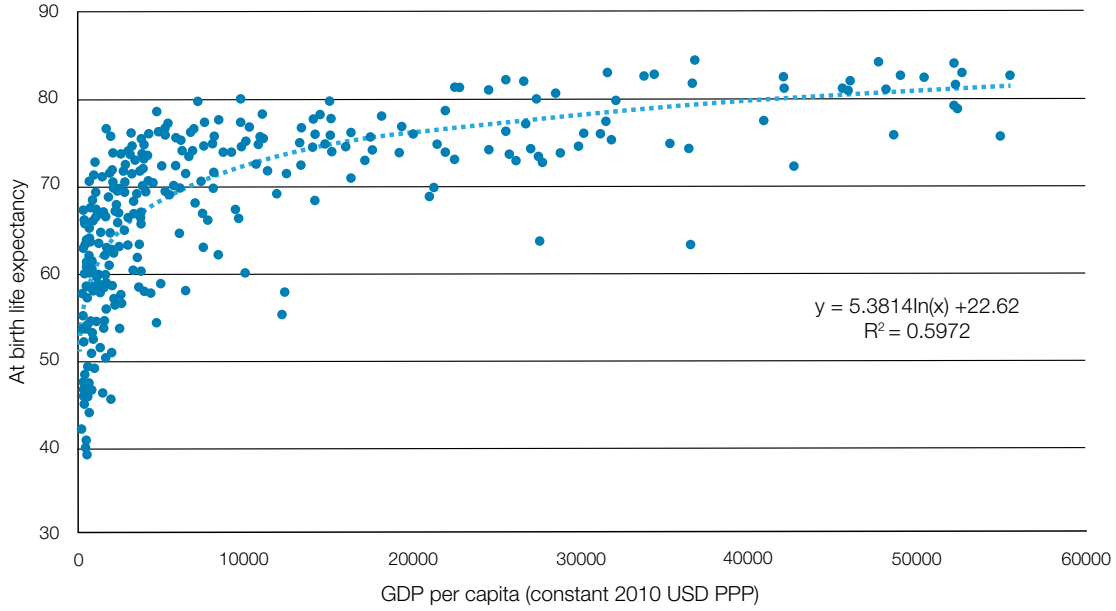
- Based on our analysis of OECD data we find life expectancy is positively associated with productivity. As life expectancy rises, this leads to increased output per hour worked, per worker and per capita.
- Using an instrumental variables approach, we find the relationship to be robust to different productivity measures, the inclusion of a range of explanatory and control variables and different instruments.
- In our analysis, life expectancy is a more powerful determinant of productivity than either the young or old age dependency ratios.
- When investigating the channels through which life expectancy boosts productivity, we find education to be more important than employment. In this context, rising life expectancy raises the returns to education.
- Overall, our analysis suggests that there may well be a longevity dividend, whereby improvements to health result in wider economic and productivity gains in developed countries.
- Improving health and raising life expectancy must therefore remain a key goal not only for a nation's health and wellbeing but also for the wider economy.
- Public policy and economic forecasters should consider how best to take into account the potential fiscal benefit of better health and not neglect it in discussions of our long run sustainability.

Introduction

The relationship between a countries' level of income and its life expectancy has been frequently explored. The so called "Preston Curve", first described by demographer Samuel H. Preston in 1975 shows that individuals born in richer countries, on average, can expect to live longer than those born in poor countries[1]. But this relationship is non-linear – life expectancy among richer countries is less sensitive to the level of income so it flattens out towards the right hand side of the chart below.

[1]Preston, S. H (1975). "The Changing Relation between Mortality and Level of Economic Development". Population Studies. 29 (2): 231–248

Figure1: **Preston curve (2016)**



Source: World Bank and author's calculations

The positive relationship between income and life expectancy has been demonstrated across many different time periods but the causes of the relationship are much debated. In particular, there is a pertinent question about the direction of the relationship – does higher income lead to higher life expectancy or does higher life expectancy lead to higher income? This report is devoted to exploring the latter relationship. More specifically, based on previous theory and evidence, we develop a statistical method for assessing the extent to which differences in life expectancy explain cross country variation in productivity – measured in terms of GDP per hour worked, per worker and per capita. We also explore two of the potential channels through which life expectancy might influence productivity – increased educational attainment and greater participation in the labour market.

How might life expectancy be related to economic output?

In our most recent analysis, we explored the potential for different age dynamics, health and education to impact on productivity within a single country – showing how each attribute effected local area productivity. The research revealed that: 1) healthier and better educated local authorities were more productive, 2) local authorities with older workforces were less productive and that 3) local authorities that were ageing the quickest also saw faster rates of productivity growth[2].

While our previous research focussed on possible reasons why different age dynamics might affect productivity differently, this report is focussed more exclusively on the role of life expectancy. According to the wider economic literature, there are many reasons why increased life expectancy might boost economic output. Healthier workers are likely to be more productive, while longer lives may result in greater incentives to invest in schooling. The latter point is worth emphasising - if parents only expect their child to live to 40, the expected lifelong returns to investing in their education is likely to be far lower than if they are expected to live to 80. Moreover, increased returns to education will reduce the incentive to have more children, thereby dragging down the fertility rate which all else equal will raise aggregate productivity[3]. Healthier children are also more likely to attend and thrive at school increasing their knowledge and cognitive ability[4]. A third channel through which life expectancy may impact productivity is increased investment. People respond to longer lives by saving a greater proportion of their

[2]For more see Franklin (2018) Does ageing matter when it comes to workforce productivity? Report for the ILC
[3]For a detailed discussion of the theory see: Bleakley, H., and F. Lange (2009): "Chronic Disease Burden and the Interaction of Education, Fertility, and Growth," Review of Economics and Statistics, 91(1), 52–65.
[4]Bloom and Canning (2007) Commentary: The Preston Curve 30 years on: still sparking fires, International Journal of Epidemiology, Volume 36, Issue 3, 1 June 2007, Pages 498–499 https://academic.oup.com/ije/article/36/3/498/655864

income, which can then be invested back into the economy raising output[5].

Until the mid-2000s, the consensus based on cross national data was that life expectancy boosted national output. But this body of research had failed to sufficiently account for endogeneity in the analyses[6]. In other words, unmeasured factors were associated with the increases in both life expectancy and output. Indeed, it is ultimately theoretically ambiguous as to whether life expectancy will boost output at the macro level. At an individual level, improvements to health should lead to increased educational attainment and more years in the labour force which should boost individual lifetime productivity, but at the macro level an increase in life expectancy is likely to lead to an increase in the size of the population which, all else being equal, will result in a fall in output per person.

In a seminal paper which seeks to address endogeneity issues, Acemoglu and Johnson (2007), find that changes in life expectancy have a large effect on the size of the population; a 1% increase in life expectancy leads to an increase in population of 1.7-2 percent but a negligible effect on GPD per person. This leads them to conclude that "there is no evidence that the large [worldwide] increase in life expectancy raised income per capita" [7].

The story does not end here however. While not doubting the validity of Acemoglu and Johnson's findings, Cervellati and Sunde (2011) argue that the effects of life expectancy on output are likely to be different depending on whether or not the country has experienced a demographic transition – which they define as a situation where life expectancy has risen above 50 and the fertility and birth rate have markedly declined. For these older countries, subsequent increases in life expectancy are associated with falling fertility, and increased incentives to invest in education which ultimately boost productivity per person. Their central conclusion is therefore that "improvements in life expectancy…reduce population growth and foster human capital accumulation after the onset of the demographic transition" [8].

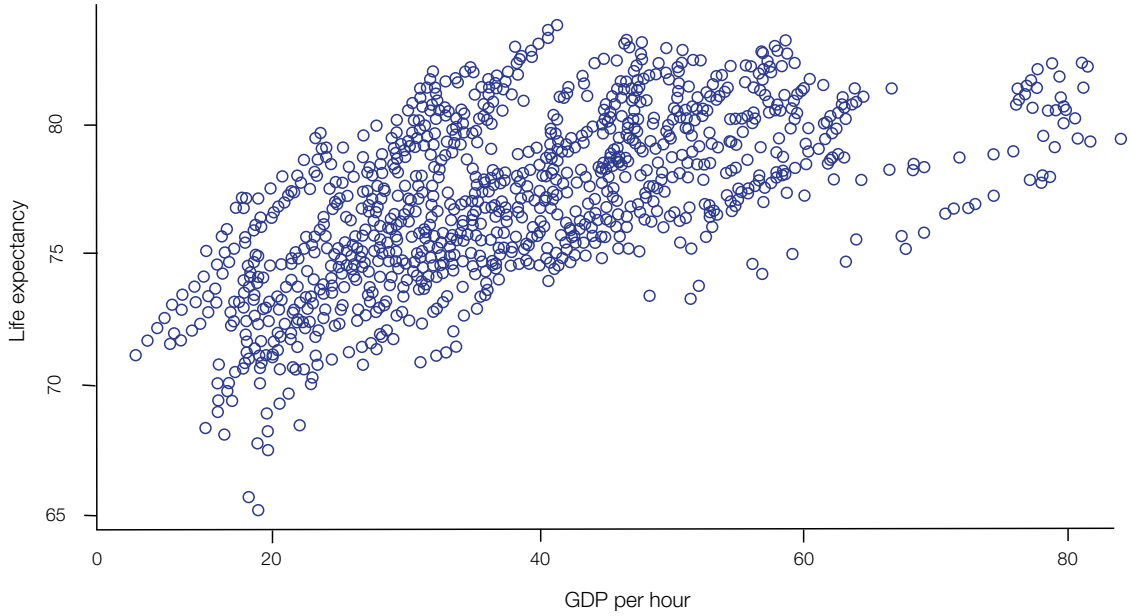
Measuring the link between life expectancy and productivity

As an extension to previous literature, we explore the relationship between life expectancy and various measures of productivity across OECD countries between the years 1970-2015. While the previous literature has focussed heavily on GPD per capita, we use three different measures of productivity: GDP per hour worked, GDP per worker and GDP per capita. We use all three because population dynamics may impact the productivity of the workforce differently to the productivity of the population as a whole. For instance, an increased share of older retired people is likely to act as a drag on GDP per capita but its effects on the productivity of the workforce itself remain contentious[9].

The work of Cervellati and Sunde (2011) finds that rises in life expectancy are positively related to output in countries that have experienced the demographic transition. Since our analysis focuses on developed countries between the years 1970-2015, we would therefore expect a positive correlation between life expectancy and our measures of productivity. Figure 2 shows this correlation in its simplest terms, a scatterplot of life expectancy against productivity per hour for OECD countries between 1975-2015. Life expectancy is positively correlated over place and time, but clearly we need to adopt more sophisticated methods to demonstrate causation.

[5]In the classic Solow growth model, increased savings results in greater investment boosting steady-state output.
[6]In econometrics, an endogeneity problem occurs when an explanatory variable is correlated with the error term. In this case the explanatory variable is life expectancy.
[7]Daron Acemoglu & Simon Johnson, 2007. "Disease and Development: The Effect of Life Expectancy on Economic Growth," Journal of Political Economy, University of Chicago Press, vol. 115(6), pages 925-985, December.
[8]Cervellati, Matteo and Uwe Sunde. 2011. "Life Expectancy and Economic Growth: The Role of the Demographic Transition." Journal of Economic Growth 16(2): 99-133.
[9]There is little consensus in the wider economic literature on the workforce productivity impacts of ageing.

Figure 2. **Scatterplot of life expectancy and GDP per hour 1970-2015 (35 countries)**



Source: OECD and author's calculations

Our statistical model

In order to test the relationship between life expectancy and productivity, we build a statistical model. In the baseline model, the log of productivity is a function of at birth life expectancy, the old age dependency ratio, the youth dependency ratio, country specific effects and time specific effects[10]. The model therefore allows us to explore the effects of life expectancy on productivity after controlling for a range of other potential determining factors. Its specification is loosely based on a recent paper by Aiyar et al. (2016) which explored the cross-national relationship between age and productivity[11].

We then seek to identify the channels through which life expectancy influences productivity by exploring the relationship between 1) life expectancy and educational attainment and 2) life expectancy and the employment to population rate. For these additions, we use the same set of explanatory variables, country specific and time specific effects. All data is taken from the OECD's statistical database: OECD.Stat[12].

Baseline results

Using Ordinary Least Squares (OLS), we obtain the following baseline econometric results (see Table 1). First, there is a positive relationship between life expectancy and our three measures of productivity. Indeed, of all the explanatory variables, life expectancy exhibits the strongest relationship across all of the productivity measures. The youth dependency ratio exhibits a very weak negative relationship with all productivity measures, while the old age dependency ratio only shows a statistically significant and very weak (negative) relationship with GDP per person.

[10]Productivity is measured in constant prices purchasing power parity terms. We take the log of productivity (base 10). For time specific effects, rather than using every year, we include decadal dummies. This means we retain more degrees of freedom within the model while still controlling for time-related economic events.

[11]Shekhar Aiyar, Christian Ebeke and Xiaobo Shao (2016) The Impact of Workforce Aging on European Productivity. IMF Working Paper https://www.imf.org/external/pubs/ft/wp/2016/wp16238.pdf

[12]http://stats.oecd.org/

Table 1.**OLS estimates of the effects of life expectancy on output**

Dependent variables	GDP per hour	GPP per worker	GDP per person
Old age dependency ratio	0.001	-0.001	-0.003***
Youth dependency ratio	-0.001***	-0.001***	-0.003***
Life expectancy	**0.026*** **	**0.023*** **	**0.025*** **
Intercept	-0.413***	3.121***	2.760***
Country fixed effects	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes
Degrees of freedom	1,080	1,080	1,080

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05

These results provide some initial support for the notion that rising life expectancy helps boost productivity. But as we have seen, there is a critical challenge around the direction of causation – do rises in life expectancy boost productivity or does rising productivity boost life expectancy? In order to deal with this issue, some researchers simply use lagged versions of the key explanatory variable in their OLS models. In our case, this would mean using a previous year's value for life expectancy to explain productivity today. The intuition here is that productivity today is unlikely to have impacted life expectancy yesterday so we can be confident of the causal association between life expectancy and productivity. However, this approach has been refuted in the economic literature[13]. Instead, best practice is to estimate a two stage least squares regression – whereby so called instrumental variables are used to provide unbiased estimates of the effects of the endogenous variable (in this case life expectancy) on the dependent variable (in this case productivity).

Instruments must be both valid, in terms of being exogenous, but also sufficiently correlated with the endogenous variable. Since it is not possible to test the former, the rationale for the choice of instrument is important and it may be worthwhile using different instruments to see if the relationship remains robust. In this context, we take two different approaches. First, loosely akin to Aiyar et al (2016) we use long lags for all of our explanatory variables – life expectancy, old age and young age dependency ratios. The instruments are 5, 10 and 20 year lags of life expectancy, the old age dependency ratio and the young dependency ratio[14]. We use long lags based on the supposition that this will reduce any correlation between the instrument and the disturbances in the error term of the original OLS regression. The trade-off here is that instruments are likely to become increasingly weak the longer the time lag and it reduces the number of observations[15]. But even using such long lags is potentially problematic if the equation error or omitted variables are serially correlated[16]. For an added robustness check, we use another instrument for life expectancy. Husain (2012) persuasively argues that worldwide vaccination programmes are an example of public health initiatives that do not necessarily depend on national income level[17]. Many such programmes have been global in scale and have applied to countries irrespective of their stage of economic development. We therefore use the childhood vaccination rate for diphtheria, tetanus, and pertussis as our alternative instrument for life expectancy – time series data on this is available from the OECD[18].

[13]See for instance, Reed (2015) On the Practice of Lagging Variables to Avoid Simultaneity, Oxford Bulletin of Economics and Statistics, Vol. 77, Issue 6, pp. 897-905, 2015

[14]Lagged variables can be used as effective instrumental variables assuming they are not correlated with the error term and sufficiently correlated with the endogenous explanatory variable.

[15]For more on this see: Murray (2006) Avoiding Invalid Instruments and Coping with Weak Instruments, Journal of Economic Perspectives—Volume 20, Number 4—Fall 2006—Pages 111–132

[16]Serial correlation is the relationship between a given variable and itself over various time intervals

[17]Muhammad Jami Husain, 2012. "Alternative Estimates of the Effect of the Increase of Life Expectancy on Economic Growth," Economics Bulletin, AccessEcon, vol. 32(4), pages 3025-3035. https://ideas.repec.org/a/ebl/ecbull/eb-12-00663.html

[18]Childhood vaccination rate passes the "weak instrument" test rejecting the null hypothesis that all instruments are weakly correlated with the

Results 2.0

Table 2 outlines the results from the instrumental variable regressions using long lags as the instruments. Life expectancy remains positively associated with productivity and this relationship is robust to different measures of productivity and different time lags as instruments. In only one case is the relationship statistically insignificant and that is when applying a 20 year lag and using productivity per worker as the measure of productivity. For all other specifications, life expectancy remains statistically significant and positive. By contrast, the old age and young age dependency ratios exhibit a very weak negative association with GDP per person when using their 5 and 10 year lagged values as instruments. Overall, these results provide stronger support for the notion that life expectancy boosts productivity in developed countries and that life expectancy is a stronger determinant of productivity than age structure more broadly.

Table 2.**Controlling for endogeneity bias instrumental variables estimates**

Dependent variables	GDP per hour	GPP per worker	GDP per person
Old age dependency ratio	0.000	-0.001	-0.003***
Youth dependency ratio	-0.001***	-0.001***	-0.003***
Life expectancy	**0.01*** **	**0.007*** **	**0.006*** **
External instruments	5 year lagged LE, OADR, YDR	5 year lagged LE, OADR, YDR	5 year lagged LE, OADR, YDR
Country fixed effects	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes
Degrees of freedom	905	905	905
Old age dependency ratio	0.001	0.000	-0.003***
Youth dependency ratio	0.001	0.001	-0.002***
Life expectancy	**0.033*** **	**0.024*** **	**0.03*** **
External instruments	10 year lagged LE, OADR, YDR	10 year lagged LE, OADR, YDR	10 year lagged LE, OADR, YDR
Country fixed effects	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes
Degrees of freedom	731	731	731
Old age dependency ratio	0.015	0.037	-0.01
Youth dependency ratio	0.017	0.047	-0.018
Life expectancy	**0.022** **	**0.021**	**0.015***
External instruments	20 year lagged LE, OADR, YDR	20 year lagged LE, OADR, YDR	20 year lagged LE, OADR, YDR
Country fixed effects	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes
Degrees of freedom	401	401	401

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05

endogenous variable life expectancy.

As we noted earlier, lagged variables can still be endogenous if the model suffers from serial correlation. For an additional robustness check, we use the vaccination rate among children for diphtheria, tetanus, and pertussis as the instrument for life expectancy. In this model, life expectancy remains positive and statistically significant in its relationship with all of the productivity measures.

Table 3.**Controlling for endogeneity bias using vaccination as instrument** [19]

Dependent variables	GDP per hour	GPP per worker	GDP per person
Life expectancy	**0.023*** **	**0.02*** **	**0.035*** **
External instrument	Childhood vaccination rate	Childhood vaccination rate	Childhood vaccination rate
Country fixed effects	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes
Degrees of freedom	959	959	959

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05

Education or longer working lives: how does life expectancy boost productivity?

So far this report has provided strong evidence for the positive effects of life expectancy on productivity in developed countries. The next critical question is what mechanisms are driving this relationship? Earlier in this report, we suggested two key factors that could explain why rising life expectancy raises output in developed countries. First is education – all else remaining equal, longer lives should raise the return on investing in education. Second is labour force participation – healthier lives should allow for a greater share of individuals to participate in the labour force for longer. In this section, we test both of these potential channels.

Our methods are similar to those outlined above. We use the same instrumental variable approach in order to account for potential endogeneity, though for expediency we only report results using the 10 year lagged values. Again we use the childhood vaccination rate as an alternative instrument for life expectancy to check the robustness of our results. Our education variable is the share of the 25-64 year old population with tertiary education, the labour force variable is the total employment to population rate. We would expect rising life expectancy to be related to an increased share of people with tertiary education and a higher employment to population rate.

Results

The results show that improvements in life expectancy boost the share of the labour force with tertiary education, but have not resulted in increased employment. This relationship is robust to both types of instruments used. Education therefore seems the most powerful channel through which life expectancy has generated increased output. Using 10 year lags as instruments, we find a higher youth dependency ratio is negatively correlated with the education share presumably because this group are by definition not yet part of the labour force and in the process of being educated. Rising dependency (both young and old) is negatively (weakly) related to the employment to population ratio which makes sense as these dependent individuals are unlikely to be in the workforce.

[19] Due to the concern that all demographic variables are endogenous, we exclude the dependency ratio controls from this specification and only include the exogenous instrument for life expectancy (vaccination rate), country and time specific effects.

Table 4.**The role of education and employment**

Dependent variables	Tertiary education	Employment to pop. rate
Old age dependency ratio	0.005*	-0.005***
Youth dependency ratio	-0.013***	-0.006***
Life expectancy	**0.019*** **	**-0.008***
External instruments	10 year lagged LE, OADR, YDR	10 year lagged LE, OADR, YDR
Country fixed effects	Yes	Yes
Time fixed effects	Yes	Yes
Degrees of freedom	731	532
Life expectancy	**0.09*** **	**-0.004**
External instrument	Childhood vaccination rate	Childhood vaccination rate
Country fixed effects	Yes	Yes
Time fixed effects	Yes	Yes
Degrees of freedom	629	959

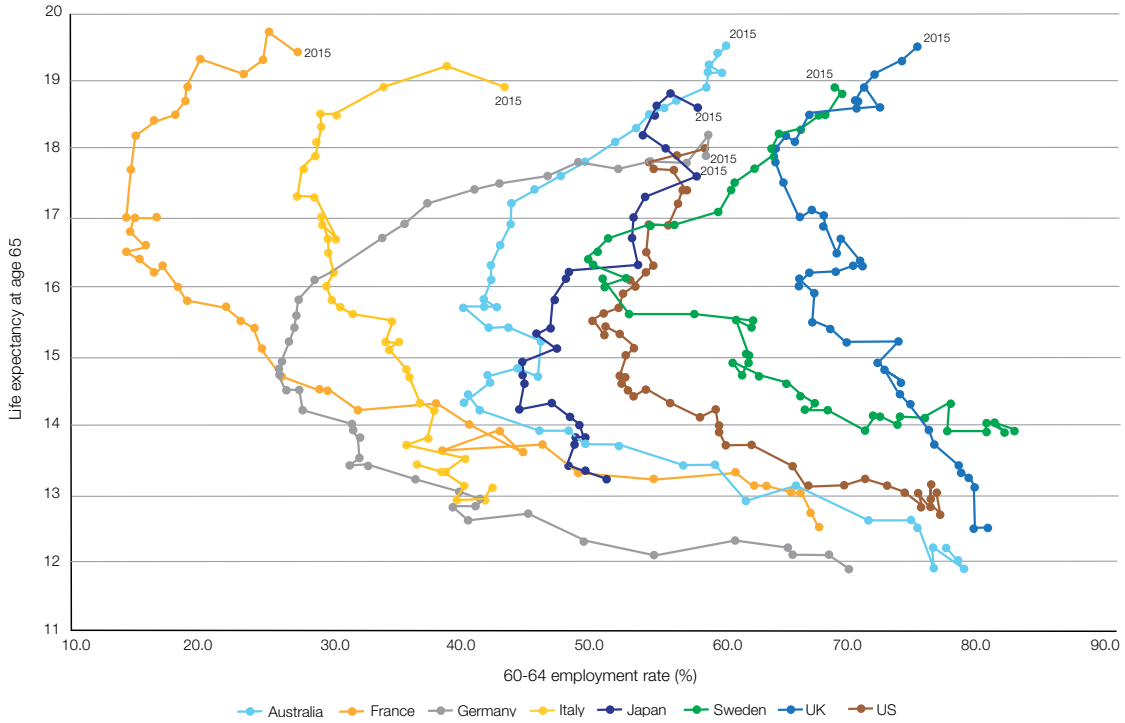
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05

Delving deeper into the employment channel

While the regression results suggest a weak negative relationship between life expectancy and employment, it is worth delving deeper into this issue. Evolving public policy and changes to private pension arrangements over a number of decades are likely to be underpinning this result. During the 1970s and 1980s a number of countries had default retirement ages in place, the age range 60-65 become the norm for pensionable age and some workers had the advantage of participating in defined benefit pension schemes. All of these developments created incentives to leave the workforce around the age of 60, irrespective of the health of individuals. It was only in the late 1990s and early 2000s with concerns brewing about the fiscal impact of an ageing population, that governments began dismantling institutional arrangements incentivising early retirements and some started to legislate for older pensionable ages. Meanwhile, corporations stopped offering their new employees access to defined benefit pension schemes as they were worried about their ability to make good on their pension promises in the wake of rising life expectancy and falling bond yields. For a number of countries, such changes resulted in a recoupling of the link between life expectancy and labour force participation.

Figure 3 below, traces the evolution of life expectancy and employment at older ages for a number of OECD countries since the 1970s. On the chart, each line represents a country, and each dot a year since 1970. The chart first shows how rising life expectancy coincided with falls in employment rates at older ages during the 1970s and 1980s, before reversing in the early 2000s as widespread public policy and private pension scheme reforms took hold. The trend since the turn of the millennium suggests there may be further capacity for rising life expectancy to translate into increased employment at older ages. Indeed, Iceland, which has one of the healthiest populations in the world, has an employment rate of 83% for 60-64 year-olds, significantly higher than the 48.9% OECD average.

Table 3. **Evolution of at 65 life expenctancy and male 60-64 employment rate (1970-2015)**



Source: OECD and author's calculations

Conclusion

This report has explored the relationship between life expectancy and productivity across a set of developed countries. Building on previous research, it has explored the link between life expectancy and three measures of productivity (GDP per hour, per worker and per person) across the OECD. Using an instrumental variables approach, we found life expectancy to be positively associated with productivity and that this relationship was robust to different productivity measures, the inclusion of a range of explanatory and control variables and different instruments. Moreover, we found life expectancy to be a more powerful determinant of productivity than either the young or old age dependency ratios.

When investigating the channels through which life expectancy boosts productivity, we found education to be more important than employment. Regarding the latter, due to changes to public policy, such as the abolition of default retirement ages and raising pensionable age, the link between life expectancy and employment at older ages has been recoupled so there is increased capacity for life expectancy improvements to translate into higher employment rates at older ages.

Overall, this analysis suggests that there may well be a longevity dividend, whereby improvements to health result in wider economic and productivity improvements. Improving health and raising life expectancy must therefore remain a key goal not only for a nation's health and wellbeing but also for the wider economy. This is important, since in many debates about long run government spending, health spending is simply seen as a drain on fiscal resources, yet if by raising life expectancy it results in productivity improvements, this could support increased tax revenue for the exchequer. Public policy and economic forecasters should consider how best to take into account the potential fiscal benefit of better health and not neglect it in discussions of our long run sustainability.

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The International Longevity Centre – UK (ILC-UK) is an independent, research led, think-tank dedicated to addressing issues of longevity, ageing and demographic change. We develop ideas, undertake research and create a forum for action and debate.

The ILC-UK was established in 2000 to explore and address the new longevity revolution and its impact on the lifecourse and society. It provides the visionary approach needed for individual and societal planning to ensure a progressive, economically viable and socially inclusive tomorrow for all.

Based in Westminster, much of our work is directed at the highest levels of government and the civil service, in London, local government and Brussels. We have a reputation as a respected think-tank which works, often with key partner organisations, to inform important decision-making processes. We are aided in this work by our Chief Executive, Baroness Sally Greengross, former director-general of Age Concern and now a cross-bench peer.

Our policy and research remit is broad, and covers everything from pensions and financial planning, to health and social care, housing design, and age discrimination. We work primarily with central government, but also actively build relationships with local government, the private sector and relevant professional and academic associations.

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