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**Article**

# Returns to Longevity? The Effects of Life Expectancy on Labour Productivity in Singapore

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## Abstract

While Singapore has consistently been at the forefront of global rankings when it comes to life expectancy and labour productivity, their relationship and interconnectedness are widely contentious. This paper attempts to specifically analyse whether life expectancy affects labour productivity through an instrumental variable approach using 2-Stage-Least-Sqaures (2SLS) regressions. I analyse the effects of life expectancy on labour productivity through multiple channels - education, savings, and the interaction between Malthusian effects and demographic transitions. While further controls must be considered to establish causality, this paper shows a positive association between life expectancy and labour productivity, shedding light that policy investments in health outcomes extend beyond demographic risk management to one which contemporaneously strengthens labour productivity.

**Keywords:** IV, Life Expectancy, Labour Productivity, Population Demographic

# 1. Introduction

*"Health is both a pre-condition of productivity and also an outcome of productivity."*

*- Civil Service College Singapore*

Lee Kuan Yew, Singapore's revered founding father once said, "our most valuable asset is in the ability of our people". An island state without any natural resource endowments, Singapore's key driver of growth has been human capital. Singapore's committed pursuit of productivity is evidenced in the establishment of various government institutions dedicated to raising productivity, such as the National Productivity Board in 1972, Productivity and Innovation Board in 2002, and Future Economy Council in 2017.

Singapore's life expectancy has experienced tremendous growth from an average of 65.7 years in 1960 to 83.5 years in 2019, the 4th highest life expectancy globally in 2019. Furthermore, global organisations such as the United Nations and World Bank predict that this rising life expectancy trend in Singapore is likely to persist for the next few decades. Concurrently, Singapore experienced significant labour productivity gains as evidenced from its output per hour soaring from a measly $3.90 to $54.55.

This paper attempts to explore the contribution of demographic and health factors, specifically life expectancy, as a driver of labour productivity. While Singapore's rapid productivity growth have often been attributed to the confluence of successful policymaking, strategic geographical location and political stability, it remains pertinent to scrutinize the linkages between life expectancy and labour productivity.

While there is extensive economic literature on the relationships between life expectancy and economic growth, and that of ageing and labour productivity, there have been relatively fewer studies examining the effects of life expectancy on labour productivity. Notwithstanding, these studies shed light on the effects of demographic factors on economic output, albeit with arguably inconsistent findings. Acemoglu and Johnson (2007) find that health effects have a nonsignificant effect on income growth and that life expectancy and economic growth are negatively related. This contrasts with a study by Ashraf et al (2008) which establishes that life expectancy is positively associated with economic growth. Additionally, some studies posit an inverted U-shape relationship between life expectancy and economic output (Cervellati & Sunde, 2011).

Empirical data postulates that countries with elevated economic output generally exhibit higher labour productivity levels. Nevertheless, this relationship varies among countries, even those with comparable GDP per capita as delineated in Figure 1. Consequently, although studies exploring economic growth provide insight into the interplay between increased life expectancy and output performance, the relationship between growth and productivity itself remains difficult to estimate. Singapore is observed to exhibit higher labour productivity in terms of output per hour worked as compared to countries with similar GDP per capita levels. This motivates the direct analysis of life expectancy on labour productivity in the unique context of Singapore.



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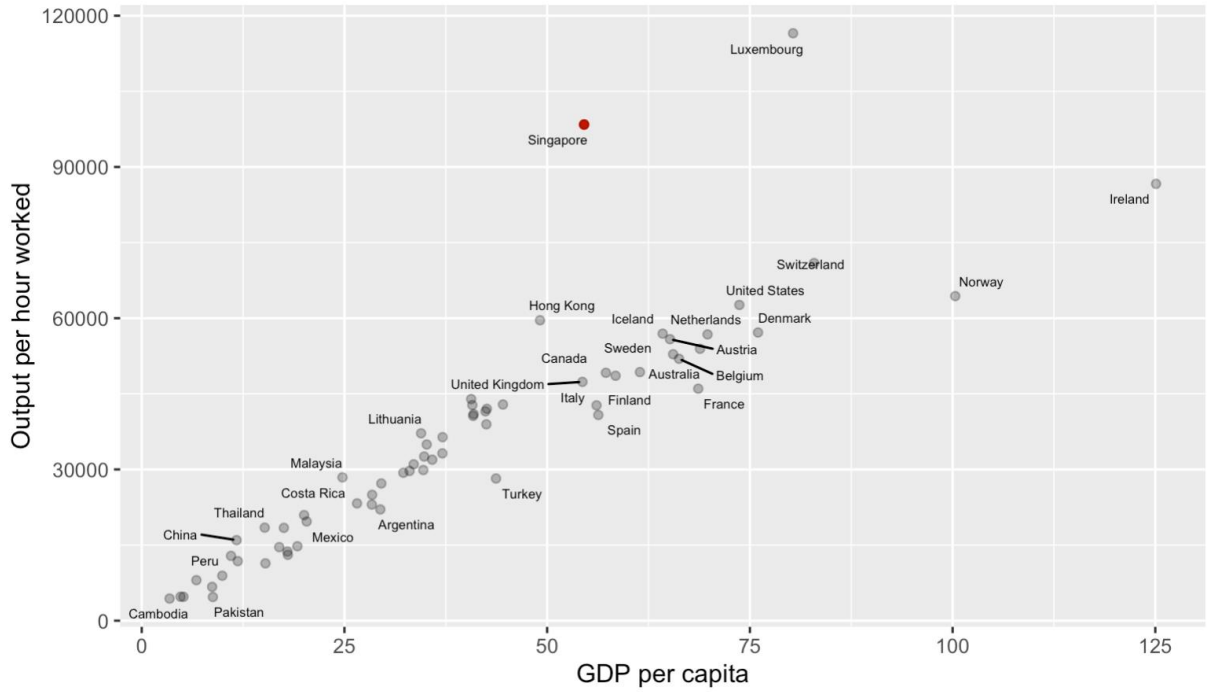


*Figure 1: Output per hour worked in international $ in 2017 prices per hour (Penn World Table) vs GDP per capita (World Development Indicators)*

Theoretically, the effect of life expectancy on labour productivity remains ambiguous due to opposing dynamics. Life expectancy is expected to increase the returns to education which boosts education attainment's effect on years in the labour force which raises incentives for higher education, thereby raising labour productivity (Kalemli et al 2000). Furthermore, higher expected life expectancy leads to an increased capital stock of the economy which enhances capital deepening and boosts labour productivity (Dua and Garg, 2019). However, in the presence of Malthusian effects, an increase in life expectancy increases population growth, which consequently reduces growth in income per capita.

This paper contributes to the existing literature by exploring the relationship between life expectancy and labour productivity in the context of Singapore and uses a two-stage least-squares statistical model in attempting to address problems of endogeneity stemming from the reverse causation of labour productivity on life expectancy. While this paper acknowledges that the relationship between life expectancy and labour productivity is likely to be casually related in both directions and that simultaneity is likely to persist, it only attempts to examine specifically the direction of the effects of life expectancy on labour productivity.

Data in this paper is limited from 1961-2019 to exclude the effects of a Circuit Breaker in Singapore as a 2020 Covid-19 response whereby physical workspaces were forced to close and work-from-home practices were mandated. The Circuit Breaker resulted in an aggregate decrease in working hours, which invariably affects labour productivity performance.



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# 2. Literature Review

## 2.1 Life Expectancy and Labour Productivity

Life expectancies in this study are taken as the expected life expectancy at birth in years as detailed in the World Development Indicators. While many studies have focused on GDP per capita as a measure of economic output and a productivity measure, this paper uses real output per hour worked as a measure of productivity. This choice of productivity specifically captures the effects of life expectancy on labour productivity for the workforce instead of the general population. Life expectancy is expected to be positively correlated with ageing which raises the pool of retired individuals which acts as a drag on GDP per capita (Oliveira Martins et al., 2005). However, wider economic literature remains divided on the effect of ageing on labour productivity across regions and sectors. In addition, real output per hour worked is used instead of real output per worker to include part-time workers and variations in hours of full-time workers across the business cycle. In the context of Singapore, labour productivity exhibits a high correlation with the real GDP, displaying highly procyclic nature. This is attributable to the firm's behaviour over the business cycle where firms are reluctant to hire or shed workers during booms and recessions but rather adjust their factor utilisation rates (Kuan, 2022). As such, accounting for the procyclicality of labour productivity, labour productivity should be observed over longer time periods to reflect changes across various business cycles. This paper analyses the data from 1961 to 2019, capturing labour productivity performance over multiple business cycles.

## 2.2 Linkages between Life expectancy and Productivity

### The Education Channel

Life expectancy raises incentives for education investment which increases the level of educational attainment of workers (Cervellati and Sunde 2013). Longer life expectancy boosts education attainment's effect on the increased years in the labour force, encouraging higher uptake of education. A study by World Bank (2020) further revealed that for every additional increase of 8.3 years of life expectancy, individuals undertake one additional year of education. As the level of educational attainment of workers increases, the stock of skilled professionals in the country increases which promotes complements with complex machinery and technologies, pertinent to jobs in knowledge-based economies (Annabi, 2017). There is wide consensus in economic literature that schooling and skills training has a positive effect on the marginal product of labour and the output produced per unit of labour, reflecting labour productivity gains. Furthermore, research evidence suggests that higher education attainment indeed raises productivity rather than a signalling ability (Chevalier et al., 2004).

Beyond the effect of raising the quality of human capital, the education channel affects labour productivity through its negative effect on the fertility rate (Cervellati and Sunde, 2011). As the returns to education increase with higher life expectancy, the incentive to have children decreases. Females who have additional years of schooling are more inclined to pursue professional careers which delays the decision of having children, as outlined by Martin, (1995). Ashraf (2013) further asserts that the decreased fertility rate is then expected to raise aggregate productivity through the "childcare effect" as parents have a greater stock of time that can be devoted to labour.



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### The Savings Channel

As life expectancy increases, the level of precautionary savings is expected to increase as workers save a larger proportion of income for retirement. Bloom et al. (2003) find that the increase in life expectancy leads to higher savings rates at every age. Similarly, a study by Sheshinski (2006) reveals that while aggregate steady-state savings rises with higher levels of life expectancy, the age distribution and elasticity of optimum retirement to longevity both determine the extent of this savings increase. While Singapore has a compulsory savings and pension scheme, the "Central Provident Fund" (CPF) that involves the co-savings of both employee and employer, where the percentage of the salary as the employer's share declines as the employee ages. As such, we would expect that employees will increase their discretionary savings for retirement if they forecast a higher life expectancy, as outlined earlier. Famously, the classic Solow growth model posits that the increase in savings results in greater investment, which increases the capital stock in the economy. This accumulation of capital stock contributes to "capital deepening", whereby the proportion of capital stock to the number of labour hours increases. A growth accounting framework analysis by the Ministry of Trade and Industry Singapore (MTI) finds that increases in capital intensity contributed approximately 2.2 percentage points of labour productivity for growth in Singapore from 2009 to 2019.

### Malthusian Effects and Demographic Transition

Famously, the Malthusian growth models predict that an increase in life expectancy increases population growth, depressing capital-to-labour and land-to-labour ratios, hence reducing the marginal product of labour. While a seminal study by Acemoglu and Johnson (2007) finds that a 1 percentage point increase in life expectancy is associated with a 1.7 - 2 percentage point increase in population, Cervellati and Sunde (2011) assert the importance of a demographic transition in predicting the relationship between life expectancy and population growth. Referencing their model, Singapore is well characterised to have undergone the demographic transition given that life expectancy in Singapore has well risen above 50 with consistently declining fertility rates. Given the negative correlation between life expectancy and population growth observed in Singapore, the negative effects of life expectancy on productivity in the Malthusian model are immaterial, regardless of the mechanism behind the demographic transition under the hypothesis of Cervellati and Sunde (2011).

## 3. Methodology

While this paper analyses the effect of life expectancy on labour productivity, the reverse is likewise possible. Addressing endogeneity stemming from reverse casualty and guided by the empirical neoclassical growth specification model used by Acemoglu and Johnson (2007) in their estimation of the causal effect of life expectancy on income per capita, this paper employs a two-stage-least-squares (2SLS) to estimate the effect of life expectancy on labour productivity.



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**Model:**

| **Regression Specification:** | |
|---|---|
| $log(Y_t) = \beta_0 + \delta_t \boldsymbol{X}_t + \beta_1 log(LifeExp_t) + \epsilon,$ | |
| $Y_t$ | Output per hour worked ($/hour, inflation-adjusted) |
| $\boldsymbol{X}_t$ | Vector of control variables, including:<br>● Trade Openness (Trade as % of GDP)<br>● Young Age Dependency Ratio (ratio of $\frac{Population\ age\ \leqslant 15}{Population\ age\ 15-64}$)<br>● Old Age Dependency Ratio(ratio of $\frac{Population\ age\ \succ 64}{Population\ age\ 15-64}$) |
| $LifeExp_t$ | Life Expectancy (Expected life expectancy at birth, instrumented by lagged life expectancy of 1,3 and 5 years |

*Table 1: Model Variables*

Young Age Dependency Ratio (YADR) and Old Age Dependency Ratio (OADR) are commonly used indicators to shed light on the state of the age-group cohort of workers. In addition, it represents the composition of workers and their obligations to household care-giving such as taking time off work to attend to healthcare needs of elderly family members or caregiving duties to infants and young children.

Trade openness was included as a control in consideration of the export-led productivity hypothesis in attempt to disentangle the effects of trade-led productivity effects on labour productivity from that of life expectancy, given that Singapore has one of the highest trade openness in the world. Additional country specific characteristics were excluded given that the regression analysis is applied to only Singapore and not a panel of countries.

To address the issue of endogeneity I use lagged life expectancy as the instrumental variable for the endogenous variable of present life expectancy. Instruments must satisfy the assumptions of exogeneity and relevance. The relevance assumption is satisfied given that lagged life expectancy is highly correlated with present life expectancy. I argue that life expectancy in the past is not systematically correlated with current labour productivity, since present-day labour productivity is unlikely to be affected by life expectancy in the past, thus lagged life expectancy satisfies the exogeneity assumption.

However, this raises the question as to the extent of the time lag to employ the instrument. We face the trade-off where an increase in the extent of the time lag of the instrument is likely to better satisfy the exclusion restriction, but the longer time lag decreases the extent of correlation between the instrument and present life expectancy, and we further lose observation counts in our analysis. As such, for sensitivity analysis, we include regression results using 1,3 and 5-year lags of life expectancy as instruments.



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# 4. Results and Discussion

We provide some descriptive analysis of the life expectancy and productivity statistics used in our regression. Broadly, the scatterplot in Figure 2 suggests a positive correlation between life expectancy and labour productivity.

| | Mean | Min | Max | Standard Deviation |
|---|---|---|---|---|
| Output per hour worked($) | 74.8419 | 65.65983 | 83.49756 | 5.469317 |
| Life Expectancy (years) | 24.91061 | 3.900617 | 55.62515 | 15.42853 |
| Trade Openness (% GDP) | 328.8891 | 229.0534 | 437.3267 | 48.9365 |
| Young-Age Dependency Ratio | 39.17178 | 15.89687 | 87.54266 | 22.38267 |
| Old-Age Dependency Ratio | 7.886815 | 3.275036 | 16.1324 | 2.484249 |

*Table 2: Summary Statistics of Data (59 observed periods 1961-2021)*



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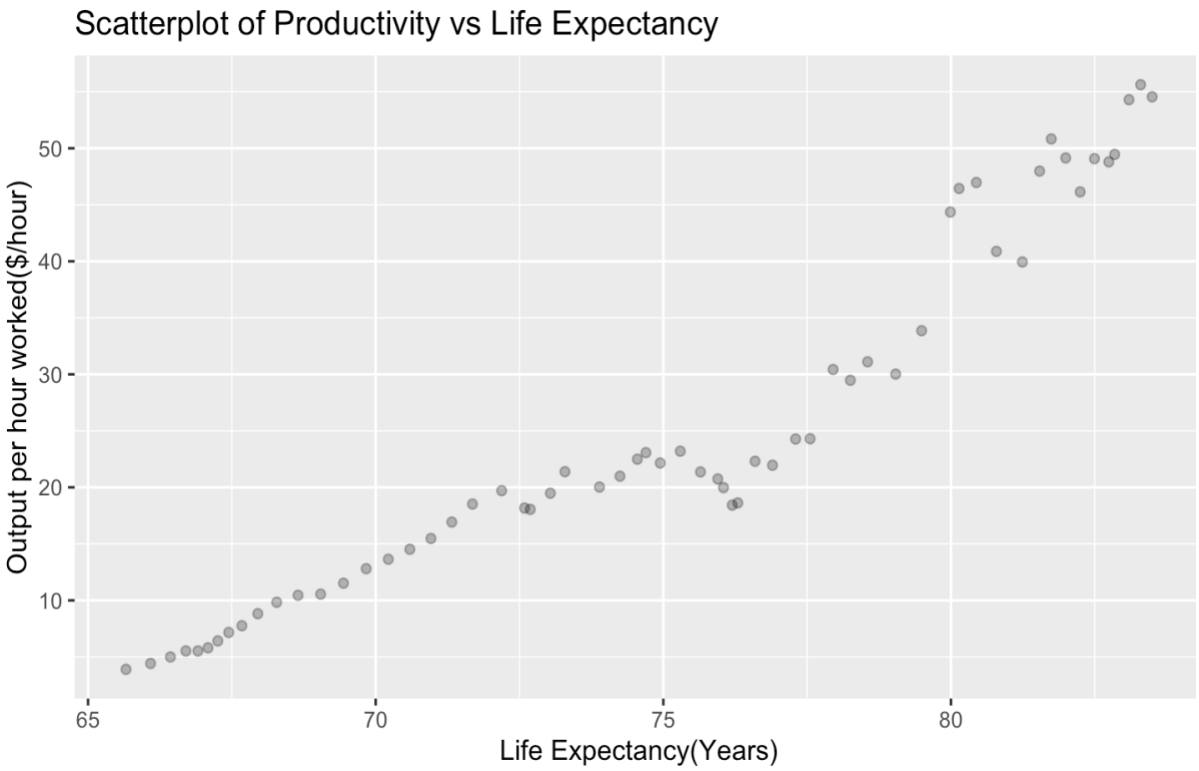


*Figure 2: Scatterplot of Output per hour worked($/hour)(Penn World Table) vs expected Life Expectancy(Years)(World Development Indicators)*



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This table summarises the regression results employing lagged log life expectancy of 1,3 and 5 years respectively as the instruments.

| Dependent Variables | log(Output per hour worked)<br>(1-year lagged life expectancy as the instrument) | log(Output per hour worked)<br>(3-year lagged life expectancy as the instrument) | log(Output per hour worked)<br>(5-year lagged life expectancy as the instrument) |
|---|---|---|---|
| log(Life Expectancy) | 3.553847***<br>(0.778016) | 3.748331***<br>(0.8345053) | 4.326918***<br>(0.8706803) |
| Trade Openness | 0.0017039***<br>(0.0004519) | 0.0019365***<br>(0.0004563) | 0.0020157***<br>(0.0004409) |
| Young Age Dependency Ratio | -0.0100618***<br>(0.0021616) | -0.0083206***<br>(0.0023329) | -0.0057029***<br>(0.0025694) |
| Old Age Dependency Ratio | 0.0633977***<br>(0.0183787) | 0.0641357***<br>(0.0182955) | 0.0611554***<br>(0.0174422) |

Table 3: Regression results

* Significant at 10%, ** Significant at 5%, *** Significant at 1%

(robust standard errors presented in parenthesis)

Additionally, considering the potential for endogeneity bias stemming from the reverse causality of productivity on life expectancy, I performed relevant specification tests. First, I perform the endogeneity tests to ascertain if the endogenous regressors are, in fact, exogenous. The Hausman test rejects the claim that life expectancy is an exogenous variable and that 2SLS should be used instead of an OLS model. In addition, I perform the F-tests to assess the validity of the instruments. The Kleibergen-Paap F statistic suggests that the instruments are valid across the 1,3,5-year lagged life expectancy as the F-statistic across all three instruments at the first stage regression is much higher than the rule of thumb critical value of 10.

Table 3 shows that across the three instruments, the coefficient estimates remain largely comparable in terms of direction, magnitude, and statistical significance. The regression estimates suggest that life expectancy is positively associated with labour productivity and is statistically significant at 1% across the lagged life expectancy instruments. These results provide support in line with economic literature that life expectancy in Singapore is expected to raise labour productivity and are consistent with that of Cervellati and Sunde (2011) in finding that countries such as Singapore, which are characterised by declining fertility rates and life expectancy well above 50, will not experience the onset of Malthusian effects. Further analysis indicates the negative association between life expectancy and population growth rate across the time period used in the paper.



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For brevity, discussing results from the IV regression with 3-year lagged life expectancy as the instrument, a 1 percentage point increase in life expectancy is expected to be associated with a 3.75 percentage points increase in output per hour worked on average. Comparing the magnitudes of coefficient estimates, we observe that the effect of life expectancy on labour productivity is much higher than that of both the YADR (-0.00832) and OADR(0.0641) and can broadly classify that life expectancy affects labour productivity more than the existing age structure composition of the economy.

Additionally, as life expectancy in Singapore is expected to increase in the following decades, we can expect workforce ageing and a reduction in the labour supply growth. While this study suggests positive returns to increased life expectancy, with such low fertility rates in Singapore, we would expect an ageing workforce accompanied with a falling labour force participation rate, due to preferences for retirement and skills obsolescence among older workers. Furthermore, wages of the older workers need not necessarily reflect labour productivity similar across different age-cohorts as older workers may be paid more than their marginal productivity possibly due to deferred compensation structures that firms may adopt.

# 5. Conclusion

While much research has been done to determine the drivers of labour productivity growth in Singapore, such as wage supplement schemes, capital intensity strengthening, and productivity solutions grants, this paper provides the angle of population demographics and health outcomes in terms of life expectancy in furthering labour productivity in Singapore. As such, this paper raises the pertinence of the improvements in health outcomes and extending life expectancy in Singapore as a policy outcome of raising labour productivity. The improvement of health outcomes has typically been viewed as demographic risk management of ageing societies such as Singapore. However, this paper suggests that investments in health conditions to improve life expectancy should be consequentially considered as a key driver of labour productivity, and by extension economic growth in Singapore.

While this paper aggregates labour productivity in Singapore across the labour force, further research can be done to analyse the effects of labour productivity across sectors given that labour quality improvements are likely to affect sectors differently. Furthermore, different measures of labour productivity can be considered to better understand the interaction between the effects of population dynamics and life expectancy on labour productivity, both across the general population

and of the labour force. Lastly, given that the reverse relationship and simultaneity are likely to hold true, where life expectancy is affected by labour productivity, it is worthwhile to examine the determinants of both life expectancy and labour productivity, such as healthcare systems and pension scheme structures.

Finally, given that productivity is comprised of many drivers beyond labour such as capital and state of technology in the economy, there is value in understanding the interactions between an ageing workforce on other productivity drivers. For instance, as the pool of older workers are likely to command higher wages increase, firms may be incentivised to uptake labour-saving capital such as



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industrial robots (Acemoglu and Restrepo, 2020), leading to differences in productivity gains between industries with greater propensity for automation relative to industries with fewer automation opportunities. Beyond raising the statutory retirement age as a mental anchor in influencing retirement decisions, to arrest the slowing labour supply growth, policies such as re-employment and job redesign can help older workers remain in employment and contribute to economic growth.



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