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Nº 331 LONGEVITY, HUMAN CAPITAL AND DOMESTIC INVESTMENT

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Longevity, Human Capital and Domestic Investment*

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Abstract

This article explores the interaction between aggregate initial human capital, life expectancy and domestic investment. The article introduces a simple model that predicts that the positive effect of life expectancy on the domestic investment rate is mitigated in economies with a higher level of initial human capital. Using a large panel of countries over the past five decades, the article presents empirical evidence consistent with the main prediction of the model.

Keywords: Domestic investment; Life expectancy; Human capital
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1 Introduction

The global average life expectancy has more than doubled since the 20th century. This demographic transition has called the attention of researchers and policy makers due to the impact that the longer life of the average population may have on economic growth through a variety of channels. However, despite a growing body of research on the relationship between longevity and growth, robust conclusions remain largely elusive. In line with much of the literature, Bloom, Canning and Fink (2014) show that both levels and improvements in life expectancy have a significant and positive effect on economic growth. However, Acemoglu and Johnson (2007) argue that improvements in life expectancy may have negatively affected economic growth.

This article examines the effect of life expectancy on domestic investment—a key engine of economic growth—and whether this effect depends on the stock of human capital (general knowledge) of the economy. We study the relationship between longevity, human capital, and domestic investment from both a theoretical and an empirical perspective. We develop a simple model that predicts that life expectancy plays a crucial role in promoting investment in economies with low initial levels of human capital, but this effect is weaker in economies with higher levels of human capital. In the model, a key channel behind this result is the effect that aggregate human capital exerts on specialization and its effect on shaping the returns to human capital relative to physical capital investments.

Using a large set of panel data of countries, we find reduced-form empirical evidence consistent with the predictions of the model: our empirical analysis confirms that the relationship between life expectancy and domestic investment is nonlinear across economies with different levels of initial human capital. We mitigate potential endogeneity concerns by estimating panel data models with country and time fixed effects, by conducting instrumental variables (IV) estimations, and by controlling for other potential nonlinear effects.

This article is related to the literature documenting positive effects of a rise in life expectancy on domestic investment and to the literature exploring nonlinear effects of longevity. Li, Zhang and Zhang (2007) show that an increase in longevity has a positive effect on investment. Cervallati and Sunde (2011) document a non-monotonic causal effect of life expectancy on income per capita growth. They emphasize that more research is needed on the issue of the appropriate specification of the empirical models, rather than focusing exclusively on the identification strategy in linear regression specifications. We contribute to this literature by exploring, at both the theoretical and the empirical level, the existence of a nonlinear relationship between longevity and domestic investment, which is a key force behind economic growth. Our theoretical analysis suggests that differences in the degree of specialization across economies with different stocks of general knowledge are a potential channel behind the nonlinearity empirically documented in this article. A formal test of the specialization channel constitutes a valuable and interesting avenue for future research.

2 A Theoretical Motivation

In this section we develop a partial equilibrium model to understand how the incentives to invest in human capital versus physical capital are shaped by a rise in life expectancy and how that relationship varies across economies with different degrees of specialization. The model highlights a novel channel through which longevity, human capital, and domestic investment interact: the role of specialization.

We study the allocation problem of an agent who inhabits an economy with a given initial stock of human capital (knowledge) and division of labor, and populated by a mass of N identical agents. Each agent is endowed with T units of time, and one unit of the unique good produced in the economy. Time is allocated across a continuum of tasks that complement each other in the production of each unit of the final good. The endowment of resources can be used to accumulate human capital or physical capital according to linear storage technology, so an investment of y units of resources produces y units of capital. Denoting by h the investment in human capital, and by k the investment in physical capital, the budget constraint of an agent is $h + k = 1$.

Production is carried out by teams of workers that perform m different tasks according to a Leontief production function:

$$Q(j) = \min_{0 \leq s \leq m} q(s, j), \tag{1}$$

where $Q(j)$ denotes the total output produced by team j and $q(s, j)$ is the output produced within each task s. Without loss of generality, we assume $m = N$.

In addition, the degree of specialization of the economy is determined by the size of the teams: bigger teams imply more specialized economies. Each team is of the same exogenous size. Moreover, following Becker and Murphy (1992), we assume that economies with a greater stock of initial human capital have bigger teams: that is, they are more specialized.[1] We denote by $H \in [H_0, H_1]$ the stock of general human capital of the economy. In addition, let the size of each team be $n = \eta(H)$, such that $1 \leq n \leq m$, $\eta(H_0) = 1$, $\eta(H_1) = m$ and $\partial\eta(H)/\partial H > 0$.

Team-specific coordination costs exist, which increase with the size of the team.[2] We denote the cost of coordinating team j by $c(j)$. Hereafter, we index each team and each individual by j. We assume that coordination costs linearly increase with the size of the team, so that $c(j) = a(j)\eta(H)$. Moreover, $a(j)$ is a stochastic component of the costs, unveiled for the agents after a team has been formed but before starting production. We assume that the stochastic component $a(j)$ is drawn from a distribution F with support $[0, \infty)$ and strictly positive pdf. Since the production technology of each task is identical within each team, each agent j allocates $t(j) = T/(m/\eta(H))$ units of time to carrying out each task.[3] For instance, in an economy with a degree of specialization $n = 4$ that must perform $m = 8$ tasks to produce one unit of the final good, an agent endowed with T units of time works in 2 tasks at the same time and allocates $t(j) = T/2$ units of time to each task.

Then, the production within each task equals the product of the working time, net of the costs of coordinating the team, and the productivity of time, which is given by the human capital of the agent carrying out the task:

$$q(s, j) = (f(t(j)) - c(j)) \times h. \tag{2}$$

[1] The authors argue that "the dependence of specialization on the knowledge available ties the division of labor to economic progress since progress depends on the growth in human capital and technologies."

[2] Becker and Murphy (1992) highlight the relevance of coordination costs.

[3] All tasks are equally difficult and have the same degree of interdependence with the other tasks. Therefore, each of the identical members of the team concentrates on an equal set of tasks m/n

As in Becker and Murphy (1992), we assume the existence of increasing returns to specialization; otherwise, there is no gain from specialization. We capture increasing returns to specialization by assuming $f(t(j)) = (t(j))^{\theta}$ with $\theta > 1$. Then the total per capita output produced by each team is equal to $Q(j)/n = \left((T/m)^{\theta}\,(\eta(H))^{\theta-1} - a(j)\right) \times h$, which is the total earnings of an agent j in the labor market. The total labor market earnings received by an agent j can be expressed as $h \times w(a(j), H, T, m, \theta)$, where $w(a(j), H, T, m, \theta) = (T/m)^{\theta}\,(\eta(H))^{\theta-1} - a(j)$ is the price in the labor market of each unit of human capital. On the other hand, investment in the capital market produces a return R, which is given for the agent, and it is collected throughout the entire life. Then, the total capital market earnings received by each agent are $k \times R \times T$, where $R \times T$ is the price in the capital market for each unit of physical capital.

We assume income-maximizer agents. Then the optimal allocation of resources $\{h^*(j), k^*(j)\}$ is such that[4]

$$\{h^*(j), k^*(j)\} = \begin{cases} \{1, 0\} & \text{if} \quad w(a(j), H, T, m, \theta) > RT \\ \{0, 1\} & \text{if} \quad w(a(j), H, T, m, \theta) \leq RT. \end{cases} \tag{3}$$

Then agents with a coordination cost such that $a(j) \geq \overline{a}(H, T; \mathcal{Z})$ invest in physical capital, where $\overline{a}(H, T; \mathcal{Z}) = (T/m)^{\theta}\,(\eta(H))^{\theta-1} - RT$ and $\mathcal{Z} = \{R, m\}$. Aggregate domestic investment, I is, thus

$$I(H, T; \mathcal{Z}) = N[1 - F(\overline{a}(H, T; \mathcal{Z}))]. \tag{4}$$

We now perform comparative statics on Equation (4) to understand the relationship between domestic investment, longevity, and initial human capital. Differentiating (4) with respect to T for both types of economies, we get

$$\frac{dI(H, T; \mathcal{Z})}{dT} = -Nf(\overline{a}(H, T; \mathcal{Z}))\left(\theta T^{\theta-1} m^{-\theta} (\eta(H))^{\theta-1} - R\right). \tag{5}$$

Let $H^* = \eta^{-1}\left((R/\theta)^{\frac{1}{\theta-1}}\, T^{-1} m^{\frac{\theta}{\theta-1}}\right)$. Suppose $\theta T^{\theta-1} m^{-\theta} < R < \theta T^{\theta-1} m^{-1}$. Since $\theta > 1$, $\partial\eta(H)/\partial H > 0$, and $f(\cdot) > 0$, then

$$\frac{dI(H, T; \mathcal{Z})}{dT} \begin{cases} > 0 \text{ if } H \in [H_0, H^*) \\ = 0 \text{ if } H = H^* \\ < 0 \text{ if } H \in (H^*, H_1]. \end{cases} \tag{6}$$

Therefore, the effect of longevity on domestic investment is positive in economies with a low initial stock of human capital but it is negative in economies with a high initial stock of human capital. This simple model shows that specialization shapes the effects that a rise in life expectancy exert on the relative returns to physical and human capital and, thus, on the incentives to invest in the capital market. Moreover, since economies with a greater initial stock of knowledge are more specialized, as the analysis by Becker and Murphy (1992) suggests, we have built a simple theory to understand why the effect of longevity on domestic investment is nonlinear across economies that differ in their stock of initial human capital or general knowledge. For instance, imagine a very generalist economy where agents must perform several tasks at the same time. Increasing returns imply that the output per individual is low in that economy.

[4]Without loss of generality, we assume that an indifferent agent always invests in physical capital.

Then, the marginal return of an extra unit of time (a rise in life expectancy) is likely to be smaller than that earned in the capital market. Therefore, domestic investment should rise more pronouncedly in this generalist economy compared with a very specialized economy that experiences the same rise in longevity. The next section provides reduced-form evidence on this issue.

3 Empirical Analysis

The sample in this study includes 108 countries over the period 1963–2012. The dependent variable is the ratio of gross domestic investment to GDP. The independent variables of interest are life expectancy at birth in years and the years of schooling of the total population in 1950. We consider a number of country-level time-varying control variables: age dependency ratio, real economic growth, GDP per capita, primary school enrollment rate, population growth, proportion of urban population, and inflation. All the variables used in this study (with the exception of years of schooling in 1950) are from the World Bank's World Development Indicators. The years of schooling of the total population in 1950 is from the Barro–Lee Educational Attainment Dataset. Table 1 reports descriptive statistics of the variables used in this study.[5]

We estimate panel data regressions to test whether the effect of longevity on investment is mitigated in economies with a greater stock of human capital. Our econometric model takes the following form:

$$I_{it} = \phi_i + \upsilon_t + \alpha T_{it} + \beta T_{it} \times HC_{i0} + \theta X_{it-1} + \varepsilon_{it}, \tag{7}$$

where I_{it} is the ratio of aggregate domestic investment to the GDP of country i during period t, T_{it} is the life expectancy, HC_{i0} is the years of schooling of the population in 1950, and X_{it-1} is a comprehensive set of covariates lagged one period. ϕ_i and υ_t are vectors of country and year dummy variables, and ε_{it} is the error term. The interaction term aims to capture the heterogeneity in the impact of life expectancy on investment across different levels of initial human capital. Consistent with our theoretical arguments, we hypothesize that $\alpha > 0$ and $\beta < 0$.

Table 2 reports the results of estimating Eq. (7). Columns 1 to 3 report OLS regressions. To mitigate potential endogeneity concerns, columns 4 to 6 report IV regressions in which we instrument life expectancy by the average life expectancy of the rest of the countries of the region.[6] Column 1 shows a positive and significant effect of life expectancy on domestic investment. An increment by one standard deviation of the life expectancy is associated, on average, with a 5.7 percentage point increase in the domestic investment rate. Column 2 shows, consistent with our model's prediction, that the positive effect of life expectancy on the domestic investment rate is mitigated in economies with a higher level of initial human capital. Column 3 shows that our results are robust to controlling for the full set of covariates. Columns 4 to 6 show that our previous results are robust to IV estimations.

[5] We clean the data in four ways. We compute five-year averages from the annual observations. We exclude observations of a variable that exceed the sample mean by more than four standard deviations. We exclude the observations in which the domestic investment rate change exceeds the sample mean by more than four standard deviations. We discard from the analysis countries with a population of less than 250,000 inhabitants.

[6] We consider six regions: Europe, Africa, Asia, Latin America and the Caribbean, Oceania, and North America.

As an additional robustness check, we test whether our main finding is driven by other potential nonlinear effects. Given that our primary variable of interest is the interaction between life expectancy and initial human capital, it is possible that these variables are proxies for other factors. One possibility is that life expectancy may capture the effect of other demographic variables, while another possibility is that initial human capital may capture other contemporaneous variables. Columns 7 and 8 report the results of an explicit test of the first possibility by including the interaction of initial human capital with mortality and fertility rates, respectively. Columns 9 and 10 report the results of an explicit test of the second possibility by including the interaction of life expectancy with GDP per capita in 1950 and regional dummies. The results reported in columns 7 to 10 show that our main findings remain qualitatively unchanged under those alternative empirical models.

4 Conclusion

Life expectancy has increased rapidly since the 20th century across several regions of the world. This demographic transition has generated considerable interest among academics and policy makers who aim at understanding the effects of longevity on economic outcomes and financial decisions. This article explores the relationship between longevity, human capital and investment from both a theoretical and an empirical perspective. The major finding of this study is that life expectancy plays a crucial role in promoting investment in economies with low initial levels of human capital, but that this role is weaker in economies with higher levels of human capital. The analysis conducted in this study improves our understanding of a specific channel (the investment cannel) through which longevity affects growth and helps to explain the mixed evidence reported in empirical studies that estimate the average effect of longevity on growth.

5 Tables

Table 1: Summary Statistics

Variable	**Mean**	**Std. Dev.**	**Min**	**Max**
Domestic Investment/GDP	0.22	0.07	0.05	0.47
Life expectancy	63.26	11.56	33.40	82.79
Life expectancy, area	63.26	9.91	44.23	81.24
HC (1950)	2.74	2.31	0.11	9.19
GDP (1950)	10.58	1.54	7.64	14.63
Mortality rate	268.38	120.46	72.71	712.39
Fertility rate	4.14	2.05	1.16	8.44
Dependency rate	0.74	0.20	0.29	1.13
Growth	3.89	3.00	-10.16	19.00
GDP per capita	7.82	1.64	4.87	11.31
Primary school enrollment rate	93.79	23.99	7.46	149.58
Population growth	0.02	0.01	-0.01	0.07
Proportion of urban population	48.15	25.45	2.32	100.00
Inflation rate	0.21	1.41	-0.03	27.19

Table 2: Domestic Investment Rates, Life Expectancy, and Initial Human Capital

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Domestic Investment Rate	**OLS**			**Instrumental Variables**			**Robustness Check 1**		**Robustness Check 2**	
Life expectancy (t)	0.0049***	0.0059***	0.0038***	0.0072***	0.0099***	0.0102***	0.0040	0.0042***	0.0071	0.0072***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)	(0.003)	(0.001)	(0.005)	(0.001)
Life expectancy (t) x H.C. (1950)		-0.0011***	-0.0011***		-0.0008***	-0.0010***	-0.0020**	-0.0011***	-0.0010**	-0.0011***
		(0.000)	(0.000)		(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)
Age dependency ratio (t)			-0.0237			-0.0026	-0.0349	-0.1628***	-0.0576	-0.0016
			(0.036)			(0.037)	(0.037)	(0.052)	(0.042)	(0.038)
Growth (t-1)			0.0045***			0.0034***	0.0045***	0.0041***	0.0055***	0.0045***
			(0.001)			(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Log GDP per capita (t-1)			-0.0001			0.0017	-0.0016	-0.0103	-0.0027	-0.0065
			(0.011)			(0.010)	(0.011)	(0.012)	(0.014)	(0.011)
Primary school (t-1)			0.0001			-0.0003	0.0001	0.0004	-0.0002	0.0001
			(0.000)			(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Population growth (t-1)			0.4968			-0.2767	0.4935	0.2332	0.5796	0.7957
			(0.546)			(0.670)	(0.538)	(0.519)	(0.580)	(0.533)
Urban population (t-1)			0.0006			0.0003	0.0007	0.0009	-0.0009	0.0007
			(0.001)			(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Inflation (t-1)			0.0004			-0.0001	0.0004	0.0002	0.0004	0.0004
			(0.001)			(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Mortality rate (t)							0.0001			
							(0.000)			
Mortality rate (t) x H.C. (1950)							-0.0001			
							(0.000)			
Fertility rate (t)								0.0178**		
								(0.009)		
Fertility rate (t) x H.C. (1950)								0.0035		
								(0.002)		
Life expectancy (t) x GDP (1950)									-0.0001	
									(0.000)	
Life expectancy (t) x Africa										-0.0048***
										(0.001)
Life expectancy (t) x Europe										-0.0052***
										(0.002)
Life expectancy (t) x LAC										-0.0037***
										(0.001)
Life expectancy (t) x Oceania										0.0004
										(0.002)
Life expectancy (t) x North America										0.0025
										(0.003)
Observations	935	870	628	935	870	628	628	628	353	628
Adjusted R-squared	0.5766	0.5726	0.5841	0.5660	0.5323	0.5151	0.5849	0.5944	0.5472	0.6012
Country fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Note: (a) Robust standard errors in parentheses. (b) *** $p < 0.001$. ** $p < 0.05$. * $p < 0.1$.

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