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Threshold Effects of Human Capital: Schooling and Economic Growth

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Abstract

Empirical growth studies have often found average years of schooling to be unrelated with economic growth. This note shows that the significant positive effect of schooling can only be realised after an economy crosses a threshold level of development.

Keywords: Human capital; Schooling; Dynamic Threshold Model; Panel Data Analysis; Growth

JEL Classification: I21; I25; O15; O40

1 Introduction

There has been a dramatic rise in schooling in developing countries between 1970 to 2010 with the average years of schooling rising by more than double (from 2.99 to 7.02)[1]. While microeconometric studies find high private rates of return for schooling, empirical growth studies have often

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[1]Source: Barro-Lee data set with the World Bank definition of developing country (92 countries available in the sample).

found an insignficant, and even negative, impact of human capital on economic growth for these countries. This has prompted a big question “Where has all the education gone?” (Pritchett 2001). In this note, we argue that an economy needs to cross a certain level of development in order to acquire the capacity to utilise the productivity of human capital efficiently.

Explanations offered to account for these apparent contradictions can broadly be divided into two strands. According to the first, it is the issue of data and differences in methodologies, for example, misspecification and measurement error (Benhabib & Spiegel 1994, Krueger & Lindahl 2001), existence of outliers (Temple 1999), and lack of data quality (de la Fuente & Doménech 2006, Hanushek & Kimko 2000, Hanushek & Wößmann 2007, Cohen & Soto 2007). But more recent studies emphasize economic reasons for these differences. Such examples include Rogers (2008) who shows that country specific characteristics such as corruption, black market premium and brain drain make human capital unproductive while Schündeln & Playforth (2014) emphasize the need to consider the social returns to human capital.

We argue that there may be a much simpler explanation, where schooling may not automatically transform into human capital because of poor educational institutions, nor be channelled into productive use due to lack of institutional efficiency in the economy [2], both of which improve with the level of development of the economy. Using a dynamic panel threshold model developed by Kremer, Bick & Nautz (2013), which is essentially an extension of the Hansen (1999) static set up, this note shows that the positive impact of human capital may not arise unless an economy is above a threshold level of development.

This note is organized as follows. Section 2 describes the data and tests for heterogeneity in the impact of average years of schooling. Section 3 presents the dynamic thresholds model and its results while section 4 presents the robustness tests. Section 5 concludes.

2 Data and Initial Test for heterogeneity

We use an unbalanced panel of 126 countries covering the period from 1970-2012. Following convention, long-run effects on growth are investigated using non-overlapping 5 year averages

[2]This may be due to a lack of institutional quality, good governance, better rule of law, freedom of speech, all of which emerge as an economy develops.

giving a total of 911 observations and 9 data points for each country[3]. The dependent variable is the growth rate of GDP per capita taken from the World Development Indicators (WDI) 1960-2013. Human capital is measured as average years of schooling taken from Barro & Lee (2013).

As control variables we use log of initial GDP per capita, gross capital formation as a percentage of GDP, population growth, trade openness (trade/GDP), financial development (M2/GDP) and government size (i.e., government expenditures as a percentage of GDP), all taken from World Development Indicators (WDI) 1960-2013. The threshold variable, capital stock per capita, proxies the level of development and is taken from Penn World Table 8.0.

Table 1: GMM and FE Estimation for Developing and Developed Countries (Dependent Variable: Growth rate of GDP per capita

	Developing Countries			**Developed Countries**		
Regressors	1 GMM	2 GMM without outliers	3 FE without outliers	4 GMM	5 GMM without outliers	6 FE without outliers
average schooling	0.259	0.716	-0.012	1.437	1.863	0.514
	[0.786]	[0.459]	[0.192]	[0.916]	[0.934]*	[0.200]**
Investment	3.151	4.027	3.416	4.643	4.512	4.652
	[1.513]**	[1.256]***	[0.578]***	[3.365]	[3.724]	[1.249]***
Trade	-0.206	-0.016	1.052	1.696	-0.556	2.450
	[1.860]	[1.910]	[0.575]*	[2.584]	[2.865]	[0.732]***
M2/GDP	-0.243	-0.833	-0.729	-1.853	-0.133	-0.642
	[1.657]	[1.514]	[0.312]**	[3.095]	[2.056]	[0.575]
Government Size	-3.168	-10.058	-3.125	-10.320	-8.695	-6.965
	[6.414]	[6.476]	[1.556]**	[4.829]**	[5.342]	[2.299]***
Population Growth	-1.546	-2.616	-0.675	-0.613	-0.164	-0.611
	[0.843]*	[0.493]***	[0.238]***	[0.742]	[0.446]	[0.152]***
Log of Initial	-0.149	-2.170	-2.420	-2.457	-1.060	-4.016
GDP per capita	[1.606]	[1.496]	[0.577]***	[1.442]*	[1.769]	[0.460]***
Observations	612	572	572	296	278	278
R^2			0.355			0.457
F	9.946	9.647	17.194	13.930	7.063	21.040
Hansen (p)	0.362	0.341		0.324	0.306	
AR2 (p)	0.959	0.979		0.693	0.756	
Countries	80	79	79	46	46	46
Instruments	23	23		23	23	

Notes: Standard errors in brackets. $*p < 0.10$, $**p < 0.05$, $***p < 0.01$. Columns (1), (2), (4) and (5) are estimated by one-step system GMM estimator. The models include time dummies. Columns (1) and (4) are without excluding outliers and columns (2), (3), (5) and (6) are after excluding outliers. Columns (3) and (6) are estimated by fixed effects estimation. The Hansen test is distributed as χ^2 under the the null hypothesis that the over identifying restrictions are valid.

Separating the samples of developed and developing countries, we estimate the following equation using fixed effects (FE) and one-step system GMM estimators:

[3]Due to the availability of data untill 2012, the last data point is the average of three years; 2010-2012. In order to see if this has biased our results, we ran the whole analysis after dropping this period. We find the same results which are available on request.

$$growth_{it} = \alpha_i + \beta_1 human\_capital_{it} + \beta_2 initial + \sum_j \beta_{jt} z_{jt} + \varepsilon_{it} \qquad (1)$$

where $growth$ is the growth rate of GDP per capita, $human\_capital$ is average years of schooling, $initial$ is log of initial GDP per capita, ε is the error term, i indicates country, and t indicates time period. z_{jt} includes all other explanatory variables.

Fixed effects averages equation (1) over time for each i and subtracts it from equation (1) to remove county-specific effects, while GMM estimation controls for endogeneity. To remove outliers, we first run one-step GMM estimation of the model and then apply the Hampel Identifier (HI), as suggested in Wilcox Rand (2005), to the regression residuals stacked over time and individual countries (R_i) and treat any observation as an outlier for which the following is true:

$$HI = \frac{|R_i - M|}{MAD/0.6745} > c \qquad (2)$$

where M is the median of observations R_1, R_2, ..., R_n, MAD is the median of the centred absolute values $|R_1 - M|$, ..., $|R_n - M|$, 0.6745 is the 75th quantile of the standard normal distribution, and $c = 2.24$ is a cut-off point.

Table 1 reports the effects of human capital on economic growth for a sample of developing and developed countries. Columns 1 - 3 show that human capital has an insignificant effect on growth in developing countries in case of both GMM and fixed effects estimation. But for developed countries, while the impact of human capital on growth is insignificant in column 4, after accounting for outliers in column 5, the human capital coefficient not only increases in magnitude but also becomes significant at 10%. In the case of fixed effects estimation in column 6, the coefficient is again positive and significant at 5%. These results motivate our argument that less developed countries experience little or no impact of human capital on growth whereas countries at a higher level of development experience a positive and significant impact.

3 Dynamic Panel Threshold Model of Human Capital and Growth

We use the dynamic panel threshold model developed by Kremer et al. (2013) in order to identify development thresholds in the relationship between human capital and economic growth ($y_{it} = dgdp_{it}$), after controlling for endogeneity of initial income (gdp_{it-1}) as a crucial regressor. In their model, by applying the forward orthogonal deviations transformation to eliminate individual effects suggested by Arellano & Bover (1995), they combine the instrumental variable estimation of the cross-sectional threshold model introduced by Caner & Hansen (2004) with the panel threshold model of Hansen (1999)[4]. The equation is as follows:

$$y_{it} = \mu_i + \theta_1 h_{it} I(k_{it} \leq \gamma) + \delta_1 I(k_{it} \leq \gamma) + \theta_2 h_{it} I(k_{it} > \gamma) + \phi z_{it} + \varepsilon_{it} \tag{3}$$

where y_{it} is the growth rate of real GDP per capita, μ_i is the country specific fixed effect, and the regime dependent variable is human capital, h_{it}, measured by average years of schooling. $I(\cdot)$ is the indicator function indicating the regime defined by the threshold variable k_{it} (i.e., the capital stock per capita), taken as the proxy for the level of development. z_{it} is the vector of exogenous (z_{1it}) and endogenous (z_{2it}) control variables with regime independent slope coeffcients. Log of Initial income (GDP) per capita ($initial$) is considered as the endogenous variable, i.e., $z_{2it} = initial$, while z_{1it} contains the remaining control variables, and δ_1 is the regime intercept common to all cross-sections, as suggested by Bick (2010).

Following Caner & Hansen (2004), Kremer et al. (2013) first estimate a reduced form regression of the endogenous variables, z_{2it}, on a set of instruments x_{it} (including z_{1it}). The predicted values of the endogenous variables, $\hat{z}_{2it}$ are then substituted into equation (3). In step two, equation (3) with $\hat{z}_{2it}$ is estimated repeatedly by least squares for each value of the thresholds, γ. Then the corresponding least square estimates of the parameters and the sum of squared errors, denoted by $S(\gamma)$ are recorded. The estimator for the threshold parameter, γ, is chosen which minimizes the sum of squared errors, i.e., $\hat{\gamma} = \arg\min_{\gamma} S_n(\gamma)$.

In accordance with Hansen (1999) and Caner & Hansen (2004), the critical values for determining a 95% confidence interval of the threshold value are $\Gamma = \{\gamma\colon LR(\gamma) \leq C(\alpha)\}$, where $C(\alpha)$ is the 95% percentile of the asymptotic distribution of the likelihood ratio statistic $LR(\gamma)$. Finally, the

[4] Please see Kremer et al. (2013) for details.

Table 2: The Effect of Human Capital on Growth: Dynamic Panel Threshold Model

Variable	
Threshold Estimate	
$\hat{\gamma}$	9.4998
95% confidence Interval	[9.4269 10.0365]
Regime-Dependent Variables	
$\hat{\theta}_1$ (coefficient below $\hat{\gamma}$)	0.2716
	(0.2287))
n	433
$\hat{\theta}_2$ (coefficient above $\hat{\gamma}$)	0.9509***
	(0.3187)
n	478
Regime-Independent Variables	
Initial GDP per capita	-13.1468***
	(1.5778)
Investment	3.6496***
	(0.8201)
Population growth	-0.3561
	(0.2968)
Trade	4.8129***
	(0.9535)
Government size	-4.6470***
	(1.1047)
M2/GDP	2.4594***
	(0.6822)
$\hat{\delta}_1$	2.7267
	(1.7968)
N	911
Hansen J(p-value)	0.4479

Notes: Standard errors in brackets.*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$. The dependent variable is growth rate of GDP per capita. The regime dependent variable is average years of schooling and the threshold variable is log of capital stock per capita. Following Hansen (1999), each regime contains at least 5% of all observations. The Hansen test is distributed as χ^2 under the the null hypothesis that the over identifying restrictions are valid.

slope coefficients are estimated by the GMM for the previously used instruments and the previous estimated threshold $\hat{\gamma}$.

The important feature of this threshold model is that it captures the impact of human capital on growth based on two different regimes. Our findings for the benchmark model, presented in table 2, show that the marginal impact of human capital on growth is regime specific with a significant capital stock per capita threshold value of around 9.4998 with a 95% confidence interval ranging from [9.427-10.037]. The confidence interval is very tight which implies that the threshold estimate has been precisely estimated, as interpreted in many other panel threshold studies (Hansen 2000, Khan & Senhadji 2001, Bose, Capasso & Murshid 2008, Henry, Kneller, Milner & Girma 2012).

The p-value for the Hansen J test is 0.4479 implying that we do not reject the null that the instruments are valid. Countries having a capital stock per capita greater than the threshold level (these include OECD and other high income countries, oil-rich and newly industrialised countries, and upper middle-income countries) experience positive and significant effects ($\hat{\theta}_2$) of human capital whereas there is an insignificant link ($\hat{\theta}_1$) between growth and human capital below this threshold level (these include African countries such as Benin, Burundi, Cameroon, Ghana, and less developed South Asian countries such as Bangladesh, Nepal and Pakistan).

Other explanatory variables are estimated with expected signs and significance. Initial income has a significant negative coefficient which confirms convergence. The estimated coefficients for both investment as a percentage of GDP and trade as a percentage of GDP are positive and highly significant, implying that increases in investment and trade tend to raise the growth rate of an economy. The coefficient for M2 as a percentage of GDP is also positive and significant. In the case of government expenditure as a percentage of GDP, the coefficient is negative and significant.

4 Robustness Tests

Table 3 reports the results of robustness tests, where column 1 uses average years of secondary schooling as an alternative measure. To deal with the issue of endogeneity, columns 2 and 3 use one-year lagged endogenous explanatory variables for total and secondary schooling.

Another important point in empirical studies is that the results may depend on the number of instruments used (Roodman 2009). In finite samples there might be a trade-off between bias and efficiency (Kremer et al. 2013) . To overcome this, with average years of schooling we use two different specifications with one including all the possible lags as instruments and the other with just one lag. Results are presented in columns 4 and 5 of table 3. Our results show that the choice of instruments has no major impact on our previous results.

As can be seen in all five columns of table 3, our previous findings remain largely robust. However, in column (2), the estimated coefficient for human capital below the threshold becomes statistically significant at 10%, though its impact above the threshold level is more than double and is also statistically significant at 1%. This supports our contention that human capital has a much greater impact at higher levels of development.

Table 3: Robustness Test: Lagged explanatory variables and Lagged instruments (Dependent Variable: GDP per capita growth rate)

	Different Schooling variables			**Lagged Instruments**	
Variable	1	2	3	4	5
	average years of secondary schooling	average years of schooling with lagged explanatory variables	average years of secondary schooling with lagged explanatory variables	Instruments one lag	Instruments all lags
Threshold Estimate					
$\hat{\gamma}$	10.0173	9.2847	9.2847	9.4750	9.4750
Confidence Interval	[9.4733 10.0556]	[9.2583 9.2951]	[8.9148 10.2964]	[9.4269 10.0486]	[9.4269 10.0556]
Regime- dependent variables					
$\hat{\theta}_1$	0.1442	0.3612	0.9480	0.2605	0.2967
	[0.4964]	[0.2119]*	[0.5825]	[0.2284]	[0.2214]
N	533	351	351	428	428
$\hat{\theta}_2$	2.3734	0.8093	1.4005	0.9168	0.9871
	[1.2367]*	[0.2591]***	[0.4522]***	[0.3185]***	[0.3093]***
N	378	434	434	483	483
Regime-Independent Variables					
Initial GDP per capita	- 12.3635	-11.5049	-11.5404	-13.3787	-12.6955
	[1.3608]***	[1.4422]***	[1.4831]***	[1.5826]***	[1.4927]***
Investment	3.0938	0.6867	0.5662	3.6155	3.6766
	[0.7642]***	[0.7596]	[0.7631]	[0.8163]***	[0.7878]***
Population growth	-0.4646	-0.5981	-0.6376	-0.3682	-0.3273
	[0.3242]	[0.2487]**	[0.2567]**	[0.2970]	[0.2891]
Trade	5.1039	4.0838	4.1031	4.8983	4.6269
	[0.9106]***	[0.9953]***	[0.9945]***	[0.9464]***	[0.9289]***
Government size	-4.5369	-5.5166	-5.4106	-4.6960	-4,5852
	[1.2290]***	[1.2576***	[1.3338]***	[1.1161]***	[1.0790]***
M2/GDP	2.6917	2.3386	2.4188	2.5601	2.2561
	[0.8375]***	[0.5175]***	[0.4972]***	[0.6781]***	[0.6595]***
$\hat{\delta}_1$	5.8900	1.4716	-0.5005	2.5806	2.8013
	[4.5475]	[1.5964]	[1.1375]	[1.7279]	[1.6417]*

Notes: Standard errors in brackets.*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$. The dependent variable is growth rate of GDP per capita. The regime dependent variable changes across all four columns. The threshold variable is log of capital stock per capita. Following Hansen (1999), each regime contains at least 5% of all observations

The coefficient estimates of trade openness, government spending and the liquidity ratio retain their signs and significance thus reinforcing our previous findings, though coefficients of investment and population growth lose significance in some cases.

5 Conclusion

The accumulation of human capital is considered as an important determinant in the process of economic growth. Despite a large literature there is still an ambiguity regarding its role in growth as a number of empirical studies have found an insignificant, in some cases even negative, impact of human capital on growth. However, the focus of these studies has been more on issues related to the use of data and methodology and they assume that the impact of human capital is the same across countries.

Using a dynamic threshold model, we show that the reason for the apparent irrelevance of human capital (proxied by average years of schooling) for generating growth in an economy lies with its level of development. This implies that human capital accumulation cannot assert its productive role in the process of growth until an economy crosses a threshold level of development. Our finding remains robust across various tests. What helps human capital to assert its productivity at a higher level of development provides an interesting opportunity for further work.

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