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A GLANCE AT GROWTH ACCOUNTING: COBB-DOUGLAS MODEL FOR G-7 (1950-2018)

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ABSTRACT

In this article, we inspected the impact of human capital on economic growth by estimating a Cobb-Douglas model for G-7 countries during (1950-2018). Our results show that, human capital has a positive impact on economic growth in the long-run with a contribution of 0.44% whereas evidence is only found for physical capital for the short-run. While the current data for G-7 with the application of pmg reveals that tfp was insignificant.

Keywords: *Human Capital, Cobb-Douglas Production Function, Growth, PMG.*

Jel Codes: *C01, D24.*

1. SOME ARGUMENTS ABOUT GROWTH ACCOUNTING

The argument about the growth of the source of East Asian countries was initiated by Young (1994) and Krugman (1994). For years, the pros and cons of Krugman-Young analysis have been examined by scholars. If the diminishing returns hold, which is an assumption of the neoclassical growth model, then capital alone cannot provide long term growth and TFP becomes important and technological development is accepted as a crucial factor for productive efficiency (Romer,1986; Lucas,1988). So by assuming constant returns to scale, physical capital, and human capital as two inputs and technology as captured by "A" is relatively unimportant in Cobb- Douglas (C-D) framework (Cobb&Douglas,1928). In addition to that, Acemoğlu and Dell (1010) have found that human capital is an important determinant of between-country and between-municipality differences.

Human capital is a crucial component of economic and industrial growth. For that reason, the impact of human capital on economic growth has taken the attention of many authors. Human capital refers to the training, experience, judgment, intelligence, relationships, insights (Barney, 1991) as well as the knowledge and skills (Hatch and Dyer, 2004; Martin de Castro *et al*., 2011; Leitner, 2011) of the individuals. Adam Smith, John S. Mill, and Alfred Marshall are considered to be the first economists talking about human capital accumulation. However modern theory of human capital is not very affected by those three, as stated by Bowman (1990). According to Smith (various additions), human capital is not much important in terms of growth. Mill (1909) on the other hand, make sense of education from a self-interest or investment motive perspective. These two motives are integral in the modern theory of human capital, constituted by Schultz (1961) and Becker (1962). One of the common points of endogenous growth models is that the importance given to physical capital over a long period is exaggerated and the most important factor in terms of growth is human capital. This study can not summarize all the literature on growth accounting, however, one must see Solow (1957) paper as one of the oldest studies within that respect K o l 998) in his analysis has also stated that skilled labor and technological spillover are more important than physical capital in growth accounting. The paper by Freire-Seren (2002) presents the empirical findings of a direct relationship between human capital accumulation and economic growth. In another empirical study by Rao and

Shankar (2012) significant estimates implied that, for a 20 year period, an additional year of education permanently added about 5% to the output growth. Finally, Wilson and Briscoe (2004) paper has examined a huge literature about GNP and human capital relationships and have concluded that investment in education has a positive and significant impact on growth.

Barro and X Sala-i Martin (1995) book is another important study of endogenous growth theories. Lucas's (1988) pioneering paper has caused many many endogeneous growth models such as Stokey (1988) Young (1991). Of course, most of the studies are affected by Romer (1986) increasing returns and other detailed features of endogenous growth models. Mincer (1995) stated that if sectoral technological growth increases than demand for an educated and trained workforce also increases. Tansel (2002) has estimated that for Turkey vocational high schools are superior to general high schools in terms of human capital. İsmihan and Özcan (2009) have shown that TFP and capital accumulation are important sources of growth, in their study where they investigated the IRF for the (1960-2004) period in Turkey. Sarkar (2007) has found that human capital is crucial for growth with its positive and significant effect on growth. Hussain (2016) paper finds that the coefficient for K and L is 0.49 and 0.51 for the Bangladesh manufacturing sector. So, the Cobb-Douglas production function exhibits increasing returns to scale for the manufacturing sector of Bangladesh. With this study, we aim to contribute to the existing literature by empirically analyzing the effects of productivity and human capital on growth for G-7 economies. In addition to that, we construct a new data set for G-7 countries in the Cobb-Douglas framework following İsmihan's (1996) paper. The study is structured as follows. In section I, a brief summary of the li is argued. In section II and III, model and the data set is investigated within a Cobb-Douglas environment. In the last section results and a discussion is provided.

2. METHODOLOGY AND THE DATA

The general practice for panel data is to estimate N separate regressions and calculate coefficient averages called mean group (MG) estimator or pool the data and assume that the slope coefficients and error variances are the same. This article uses the pooled mean group (PMG) estimator, a procedure that limits long-term coefficients to be the same but allows short-term coefficients and error variances to differ between groups. It is possible to derive the asymptotic distribution of PMG estimators, taking into account both the state that the regressors are stationary, the state in which they follow unit root processes and both cases when the time dimension goes infinity.

The model we use inspects the effect of total factor production, capital accumulation, human capital index on economic growth with a standard Cobb-Douglas production function such as:

$$Y_{it}=A.K^{a}_{it}\ H^{b}_{it} \qquad (1)$$

where, Y_{it} is GDP, K_{it} is capital, A is total factor productivity and H is human capital for representing labor. i and t represent cross-sections and t is respectively. Equation 1 is a modified form of Wooldridge (2009) model with a difference. The difference is that our model uses human capital instead of labor. Assuming that the law of diminishing returns does not exist, H (human capital index) representing human capital is preferred instead of L in the two-factor production function. Such a representation would be more appropriate if today's industry 4.0 and the existence of high-tech industries are taken into account.

The data seen below was collected from the Penn World Table version 9.1.

Y Real GDP at constant 2011 national prices (in mil. 2011US$)

K Capital stock at constant 2011 national prices (in mil. 2011US$)

H Human capital index, based on years of schooling and returns to education; see Human capital in PWT9

TFP TFP at constant national prices (2011=1)

Below panel ardl data with time periods, t = 1,2, ... ,T, and groups, i = 1,2, ... ,N, we aim to estimate an ARDL(p, q, q, ... ,q) model,

$$y_{it} = \sum_{j=1}^{p} \theta_{ij} Y_{i,t-j\ i} + \sum_{j=0}^{q} \gamma'_{ij} X_{i,t-j} + \mu_i + \varepsilon_t \quad (2)$$

Here vector of explanatory variables are Xit (k xl), μ_i shows the fixed effects; the lagged dependent variables, θ_{ij} are scalars; and γ'_{ij} are k x 1 coefficient vectors. Each group seperately estimated with a large T. The following variables are used for representation of the model:

$$\Delta logY_{it} = \beta_i[\Delta logY_{i,t-1} + \gamma'_i X_{i,t}\ ] + \sum_{j=1}^{p-1} \theta_{ij} l\Delta ogY_{i,t-j} + \sum_{j=0}^{q-1} \vartheta'_{ij}\, \Delta X_{i,t-j} + \varepsilon_t \qquad (3)$$

β_i: is the group specific speed of adjustment coefficient

γ'_i: is the long-run relationship vector

ECT = $[\Delta logY_{i,t-1} + \gamma'_i X_{i,t}]$, error correction term

$\theta_{ij}\vartheta'_{ij}$: short-run dynamic coefficients

Four procedures such as; pooling, aggregating, averaging group estimates, and cross-section regression are used in panel data. The estimates are unbiased if the coefficients differ and pooling gives inconsistent results when the coefficients differ across groups. So the cross-section provides consistent results for the long-run (Pesaran and Shin, 1995).

In principle, PMG estimators can be computed whether the regressors are 1(0) or 1(1) (Pesaran et al, 2012:625).

3. RESULTS

First we specify the model and then looking at correlation analysis, we perform unit root tests and selecting optimal lags. After looking at cointegration test and Hausman test we estimate the model and causality relationship.

Table 1. Descriptive Data

Variable	Obs	Mean	Std.Dev.	Min.	Max
Logy	483	14.31636	.9485411	12.09554	16.6897
Logtfp	483	-.1767118	.234095	-.9325089	.1250409
logK	483	15.70289	.9954217	13.28907	17.6447
logH	483	1.07335	.1745657	.5841789	1.32384

Table 2. Correlation Matrix

	Logy	Logtfp	lokK	logH
Logy	1.0000			
Logtfp	0.4969	1.0000		
logK	0.9828	0.5494	1.0000	
logH	0.6857	0.5291	0.6713	1.0000

After the correlation coefficients among the variables were found to be significant, the stationarity state of the variables was examined. Firstly, panel unit root tests of Levin et all. (LLC,2002), Breitung (2000) and Im et all. (IPS,2003) were used for statioanrity. When deciding about the optimal lag lengths, we look at the most common lag accross the countries for each of the four variables. In the next step, after choosing the optimal lag length we look for the test of cointegration with Pedroni (1999,2004) cointegration test to test the cointegration relation among the variables. Long term parameters of the variables were estimated with MG developed by (Pesaran and Smith,1995) and PMG developed by Pesaran et all. (Pesaran,1999).

Before determining the panel cointegration relationship between the series, it is examined whether or not the series are stationary to avoid the spurious regression problem. Levin et all. (LLC, 2002) proposed a panel unit root test that applies ADF seperately for each cross section. LLC assumes that all units in the panel have first order partial autocorrelation. Breitung (2000) which is a pooled panel unit root test, provides an appropriate data transformation and does not require a correction. The size of distortions are small in this test, while Im et all. (IPS,2003) proposed a unit root test for dynamic heteroheneous panels based on the average of individual unit root statistics. The results of panel unit root tests coul be seen in Table 3.

Table 3. Panel Unit Root Tests

variables	LLC (adjusted t*)	Breitung (lambda)	IPS (Z-t-tilde-bar)
level			
Logy	-1.3636	11.6813	-9.9091
	(0.0864)	(1.0000)	(0.0000)
logK	-8.0123	-5.3317	-16.2019
	(0.0000)	(0.0000)	(0.0000)
logH	-10.0671	14.4652	-7.1808
	(0.0000)	(1.0000)	(0.0000)
logtfp	-6.0543	5.2245	-3.5369
	(0.0000)	(1.0000)	(0.0002)
First difference			
d.ly	-15.6491	-16.6111	-15.7023
	(0.0000)	(0.0000)	(0.0000)
d.ltfp	-7.4092	-11.1961	-10.7941
	(0.0000)	(0.0000)	(0.0000)
d.lK	-14.6183	-15.9692	-15.3967
	(0.0000)	(0.0000)	(0.0000)
d.lH	-3.0326	-0.0058	-5.9394
	(0.0012)	(0.4977)	(0.0000)

Pedroni (1999) developed 7 cointegration tests, the first four pooled within dimension which allow heterogeneity for cointegration and the other 3 were between dimension in panel data models. The hypoheses of the test were defined as "H0:no cointegration between series" and H1 cointegration between the series". In six out of 7 statistics the null of "no cointegration" is rejected, because the values are lower than 0.05%, so we can decide about cointegration among the variables. After this step, we decide about whether pooled mean group estimator (pmg) or mean group estimator(mg) is homogeneity, pmg is the most appropriate estimator, so the model supports pmg estimator, since the probability value is greater than 0.05% level. When deciding about the dynamic fixed effects estimator and pmg estimater again we run Hausman test.

Table 4. Pedroni's Cointegration Test

Test Statistics	Panel	Group
V	1.791	.
Rho	-4.155	-3.688
T	-4.241	-4.442
adf	-2.038	-1.796

All test statistics are distributed N(0,1), under a null of no cointegration, and diverge to negative infinity.

4. PANEL ARDL ESTIMATION PROCEDURE

The advantage of the panel ardl is that a dynamic error correction moe explanatory variables fordel can be derived with a simple linear transformation. Two estimators such as mg and pmg are suggested for panel ardl. The mg estimator places no restrictions on specification parameters and derives the long run parameters from the average of the individual ardl estimators long run parameters. It also does not allow for short term heterogeneity of variables. Therefore Pesaran et all (1999) developed pmg as an alternate to mg estimator. PMG estimator reestricts the long-term coefficients and error variances to differ between groups. The pmg estimator assumes that the error terms are unrelated and are independent from the regressors. There is a long-term relationship between dependent variable and long-term parameters are the sam efor all countries. Long-term homogeneity of the parameters are tested with Hausman (1978) test.

Table 5. Panel Ardl (2,1,2,2)

Variable	Mg	Pmg	Hausman
	Long-run coefficients		
d.Ly			
Ltfp	-.0792926 (0.917)*	-.4533831 (0.004)***	.3740905
lK	-.0707371 (0.277)*	-.245691 (0.006)***	.1749539
lH	.3588833 (0.794)*	.4455232 (0.049)**	-.0866399
	Error Correction Term		
ECT	-.4075501 (0.000)***	-.3360963 (0.000)***	
	Short-run Coefficients		
Δltfp	-.3922804 (0.585)*	-.2568994 (0.709)*	
ΔlK	.0154997 (0.338)*	.0407881 (0.000)***	
ΔlH	-.6162845 (0.828)*	.5810866 (0.689)*	
İntercept	1.263865 (0.406)*	2.154987 (0.000)***	
Hausman test chi-square		-4.49	

The values in parentheses are probability values, ***,**, and * are respectively 1%,5%, and 10%

Country Analyses

	Canada	
d.ly		-.1842206 (0.000)
Δltfp		-.131135 (0.886)
ΔlK		.0213523 (0.890)
ΔlH		3.697135 (0.382)
Intercept		1.107595 (0.029)
	France	
ECT		-.3093931 (0.000)
d.Ly		
Δltfp		.2632969 (0.660)
ΔlK		.0265277 (0.789)
ΔlH		-.5097334 (0.704)
Intercept		1.956258 (0.000)
	Germany	
ECT		-.2864646 (0.000)
Δltfp		-.0128831 (0.973)
ΔlK		.0462029 (0.546)
ΔlH		-6.633842 (0.022)
Intercept		1.855709 (0.002)
	Italy	
ECT		-.5092888 (0.000)
Δltfp		2.948401 (0.008)
ΔlK		.0552888 (0.711)
ΔlH		1.513229 (0.193)
Intercept		3.331516 (0.000)
	Japan	
ECT		-.4302523 (0.000)
Δltfp		-1.67262 (0.013)
ΔlK		.0531823 (0.535)
ΔlH		-1.524403 (0.622)
Intercept		3.010206 (0.000)
	UK	
ECT		-.4009424 (0.000)
Δltfp		-2.959613 (0.026)
ΔlK		.0173488 (0.924)
ΔlH		3.835095 (0.575)
Intercept		2.457974 (0.002)

	US	
ECT		
Δltfp		-2.959613 (0.821)
ΔlK		.0656137 (0.599)
ΔlH		3.690126 (0.378)
Intercept		1.365647 (0.015)

We can see from the ECT values that there is cointegration among the variables for each country. However for long run coefficients which shows long run causality in the same time, not all three variables are significant only human capital is significant in some. The coefficients are homogeneous for the full panel in the long-run. For the short run, coefficients and error variances differ for each country. We can make a comparative analysis for each country; it can be said that for the short run the variable total factor productivity is significant for Italy which is it's coefficient is %2.94 positive impact on growth. Since it is less informative we didn't use mean grıup estimation seperately. Intercepts are positive and significant which shows the technology parameter.

5. DISCUSSION AND IMPLICATIONS FOR FUTURE RESEARCH

At this point, the data fails to meet the asymptotic assumption of Hausman test. This can be a sign of bad fit of the H0 model, then one can use diagnostic rules or as an alternative, the absolute value of the static could be preferred (Mizon and Richard, 1986). The model supports the pmg estimator with the assumption of the absolute values of the statistics. According to these results; where the human capital variable has a positive and significant effect in explaining economic growth. In the short-run, the physical capital variable has a significant and positive impact on growth.

From a cross-country perspective, in this panel covering the period (1950-2018) for G-7 countries, it is concluded that human capital has a positive impact on economic growth. In the short-run, it is concluded that physical capital has a significant positive effect on economic growth.

The contribution of this paper is that the intercept or mainly the technology parameter is significant and positive for each country and the variable of human capital is also positive 0.44% for the full panel in the long run. Our results are in line with previous studies of Pelinescu (2015), Sarkar (2007), and Hussain (2016). Future research may analyze a broader spectrum set of variables and secondly, can look for local differences.

REFERENCES

1. ACEMOĞLU, D. & DELL, M. (2010). “Productivity Differences Between and Within Countries”, American Economic Journal: Macroeconomics, 2 (1), pp. 169–188, DOI: 10.1257/mac.2.1.169.

2. BARNEY, J. (1991). “Firm Resources and Sustained Competitive Advantage”, Journal of Management, 17/1, pp. 99-120.

3. BARRO, R. J. & SALA-I-MARTIN, X. (1995). Economic Growth, McGraw Hill, New York.

4. BECKER, G. S. (1962). "Investing in Human Capital: A Theoretical Analysis", Journal of Political Economy, 70/2, pp. 9-49.

5. BOWMAN, R. S. (1990). "Smith, Mill, and Marshalion Human Capital Formation", History of Political Economy, 22/2, pp. 239-259.

6. BREITUNG, J. (2000). “The Local Power of Some Unit Root Tests for Panel Data”, Advances in Econometrics, 15, pp. 161-177, http://dx.doi.org/10.1016/S0731-9053(00)15006-6.

7. COBB, C. W. & DOUGLAS, P. H. (1928). “A Theory of Production”, The American Economic Review, 18 (1), pp. 139-165.

8. FREIRE-SEREN, M. J. (2002). “On the Relationship Between Human Capital Accumulation and Economic Growth”, Applied Economics Letters, 9/12, pp. 805-808.

9. HATCH, N. W. & DYER, J. H. (2004). “Human Capital and Learning as A Source of Sustainable Competitive Advantage”, Strategic Management Journal, 25/12, pp. 1155-1178.

10. HAUSMAN, J. A. (1978). “Specification Test in Econometrics”, Econometrica, 46 (6), pp. 1251-1271, DOI: 10.2307/1913827.

11. HUSSAIN, S. (2016). "A Test for the Cobb-Douglas Production Function in the Manufacturing Sector: The Case of Bangladesh”, International Journal of Economics and Business Research, Vol. 5, Issue. 5, pp. 149-154, DOI: 10.11648/j.ijber.20160505.13

12. İSMİHAN, M. & METİN-ÖZCAN, K. (2009). “Productivity and Growth in An Unstable Emerging Market Economy: The Case of Turkey, 1960-2004”, Emerging Markets Finance and Trade, Vol. 45, No: 5, pp.4-18; TAYLOR and FRANCIS, https://www.jstor.org/stable/27750685;
Performance of the Turkish Economy: 1960-2004, Bilkent University, Department of Economics Discussion Papers, No. 06-10, Ankara, Bilkent.

13. KİBRİTÇİOĞLU, A. (1998). “İktisadi Büyümenin Belirleyicileri ve Yeni Büyüme Modellerinde Beşeri Sermayenin Yeri”, Ankara Üniversitesi SBF Dergisi, 53, (1-4), pp. 207-230, DOI:10.1501/0002861.

14. KRUGMAN, P. (1994). “The Myth of Asia’s Miracle”, Foreign Affairs, 73(6), pp. 62-78.

15. LEITNER, K. (2011). “The Effect of Intellectual Capital on Product Innovativeness in SMEs”, International Journal of Technology Management, 53/1, pp. 1-18.

16. LEVIN, A. & LIN, C-F. & CHU, C-S. J. (2002). “Unit Root Tests in Panel Data: Asymptotic and Finite-Sample Properties”, Journal of Econometrics, 108, pp. 1-24, DOI: 10.1016/S0304-4076(01)00098-7.

17. LUCAS Jr, R. E. (1988). “On the Mechanics of Economic Development”, Journal of Monetary Economics, 22 (1), pp. 3-42.

18. MARTIN-DE-CASTRO, G. & DELGADO-VERDE, M. & LÓPEZ-SÁEZ, P. & NAVAS-LÓPEZ, J. E. (2011). “Towards ‘An Intellectual Capital-Based View of the Firm’: Origins and Nature”, Journal of Business Ethics, 98/4, pp. 649-662.

19. MILL, J. S. (1909). Principles of Political Economy, Longman, London, England.

20. MINCER, J. (1995). “Economic Development, Growth of Human Capital, and the Dynamics of the Wage Structure”, 1994-95 Discussion Paper Series No. 744, (September), Columbia University, pp. 38, DOI: 10.1080/01621459.1999.10474156.

21. MIZON, G. & RICHARD, J. F. (1986). “The Encompassing Principle and its Applications to Testing Non- nested Hypothesis”, Econometrica, Vol. 54, Issue: 3, pp. 657-78.

22. PEDRONI, P. (1999). “Critical Values for Cointegration Tests in Heterogeneous Panels with Multiple Regressors”, Oxford Bulletin of Economics and Statistics, Special Issue, 61, pp. 653-670. DOI: 10.1111/1468-0084.0610s1653

23. PELINESCU, E. (2015). “The Impact of Human Capital on Economic Growth”, Procedia Economics and Finance, 22(1), pp. 184-190.

24. PESARAN, M. H. & SHIN, Y. & SMITH, R. P. (1999). “Pooled Mean Group Estimation of Dynamic Heterogeneous Panels”, Journal of the American Statistical Association, 94:446, pp. 621-634.

25. PESARAN, M. H. & SMITH, R. (1995). “Estimating Long-Run Relationships From Dynamic Heterogeneous Panels”, Journal of Econometrics, 68, pp. 79-113, DOI: 0.1016/0304-4076(94)01644-F

26. RAO, B. B. & SHANKAR, S. (2012). “Estimating the Permanent Growth Effects of Human Capital”, Applied Economics Letters, 19/17, pp. 1651-1653.

27. ROMER, P. M. (1986). "Increasing Returos and Long-Run Growth", Journal of Political Economy, 94/5, pp. 1003-1037.

28. SARKAR, D. (2007). “The Role of Human Capital in Economic Growth Revisited”, Applied Economics Letters, 14:6, pp. 419-423, DOI: 10.1080/13504850500447323

29. SCHULTZ, T. W. (l961). "Capital Formation by Education", Journal of Poliiical Economy, 68: pp. 571-583. STOKEY, N. L. (1988). "Leaming by Doing and the Introduction of New Goods", Journal of Political Economy, 96: pp. 701-717.

30. SMITH, A. (Various Editions). An Inquiry into the Nature and the Causes of the Wealth of the Nations, Various Editions.

31. SOLOW, R. (1957). “Technical Change and the Aggregate Production Function”, Review of Economics and Statistics, Vol.39, pp. 312-320.

32. TANSEL, A. (2002). General versus Vocational High Schools and Labor Market Outcomes in Turkey, Human Capital: Population Economics in the Middle East, pp. 258-272.

33. WILSON, R. A. & BRISCOE, G. (2004). The Impact of Human Capital on Economic Growth: A Review, Impact of Education and Training. Third Report on Vocational Training Research In Europe: Background Report, Luxembourg: EUR-OP.

34. YOUNG, A. (1994). “The Tyranny of Numbers:Confronting the Statistical Realities of The East Asian Growth Experince”, Quarterly Journal of Economics, 110(3), pp. 641-80.

35. YOUNG, A. A. (1991). "Leanıing by Doing and the Dynamic Effects of International Trade", Quarterly Journal of Economies, 106/l, pp. 369-406.