

R&D and Economic Growth: New Evidence from Some Developing Countries

¹Ahmad Jafari Samimi and ²Seyede Monireh Alerasoul

¹Professor of Economics at the University of Mazandaran, Babolsar, Iran,
Pasdaran Ave, Babolsar, Iran

²MA student in economics at the University of Mazandaran, Babolsar, Iran

Abstract: R&D plays a major role in innovation, raising productivity and increasing economic growth. The purpose of this paper is to estimate the impact of R&D on economic growth of developing countries. To do so we have used a sample of 30 developing countries for which the necessary data were available for the period 2000-2006. We have also used different indicators of R&D. In other words, the share of government expenditures on research in GDP; the number of researchers in each one million population; and the scientific output of the countries were used as 3 different proxies for R&D. Our findings based on panel data regression models indicate that in general no significance positive impact exists in the countries under consideration.

Key words: R&D; Economic Growth; Developing countries; Panel Data.

INTRODUCTION

Recent theories of economic growth draw attention to endogenous technological change to explain the growth patterns of world economies. According to these so-called endogenous growth models, pioneered by Romer (1986), technological innovation is created in the research and development (R&D) sectors using human capital and the existing knowledge stock. It is then used in the production of final goods and leads to permanent increases in the growth rate of output. At the heart of these models is their postulation that endogenously determined innovation enables sustainable economic growth, given that there are constant returns to innovation in terms of human capital employed in the R&D sectors. Therefore research and development (R&D) is a key long-run determinant of productivity and economic growth. R&D constitutes the search for new technology therefore new goods and the central purpose of the economic growth theories is to understand the factors behind long-run growth and to explain differences in growth performances of economies.

In Solow (1956) and Ramsey (1928) models, the long-run growth rate of the aggregate capital accumulation completely depends on the exogenous technological progress and population growth rate. To study endogenous economic growth, many models (for example, Romer, 1996, P96; Aghion and Howitt, 1992; Grossman and Helpman, 1991; Jones, 1995) see technological progress as a production process like production of output.

A number of authors have suggested that new ideas are the engine of growth. It is not our purpose here to systematically review the literature. Instead we will briefly mention some milestones in the development of endogenous growth models with R&D. A pioneer in the area of endogenous growth is Paul Romer. Romer (1990) emphasizes the public-good character of knowledge: ideas, designs, and blueprints are in principal non-rival. However, they may be made excludable through protection by patent law and copyright law. Firms engaged in R&D are then able to protect their inventions during a certain time period and may reap the benefits from their investments. The prospect of (temporary) monopoly profits encourages firms to invest in R&D. Suppose that the production function takes the form

$$Y = A \sum_{j=1}^N K_j^\alpha L^{1-\alpha} \quad (1)$$

Where K_j is input of the j th type of the specialized intermediate good and N is the number of varieties of

the capital goods (cf. Romer (1990), Barro and Sala-I-Martin (1995)). Technological progress yields an expansion in N . In equilibrium, the production function can be rewritten to

$$Y = ANK^\alpha L^{1-\alpha} \quad (2)$$

Thus, technological change in the form of a steady increase in N is not subject to diminishing returns, and this property of the production function is essential to generate endogenous growth. The next step in the analysis is to study the expansion in the variety of products. New growth models assume that this expansion requires deliberate effort in the form of research and development. For instance, Barro and Sala-I-Martin assume that the cost to create a new type of product is fixed at η units of Y . However, most models assume some randomness in the discovery of new products (generating fluctuations at the aggregate level).

Two other economists who made important contributions on the link between R&D and economic growth are Philippe Aghion and Peter Howitt. Aghion and Howitt (1992) develop an endogenous growth model with creative destruction (based on the ideas of Schumpeter). R&D efforts can lead to innovations, i.e. improvements in the general purpose technology. Protection by patent law gives a firm the monopoly right to market a new product. The prospect of monopoly profits encourages firms to develop new and better products, so that the innovating firm can enter the market and the incumbent monopolist is replaced (Schumpeterian creative destruction). Economic growth is determined by the speed of the innovation process. The market solution may not correspond to the socially optimal solution. In the model by Aghion and Howitt, economic growth can be too high or too low. On the one hand, intertemporal knowledge spillovers can reduce R&D investments below the optimal level. By assumption, entrepreneurs only look at the returns to R&D during the life span of their company. The firm is replaced when another entrepreneur develops a better product, but this innovation builds forth on knowledge embodied in the previous product generation. Innovators thus stand on the shoulders of giants. The positive externality of intertemporal knowledge spillover leads to private returns falling short of social returns to R&D, depressing R&D activity below its socially optimal level. On the other hand, by assumption entrepreneurs do not consider the consequences of innovation for the profits of incumbent firms. Innovation yields improved products, and the existing product is driven out of the market (business stealing). The lost profits are not reflected in the private return, but they do reduce the social return to R&D. The negative externality of creative destruction thereby leads to private returns exceeding the social return, possibly triggering excessive R&D activity.

One way to model the idea that R&D matters for growth is to introduce a relationship between TFP (total factor productivity) and the R&D stock (cf. Griffith *et al.*, 2000, 2004), i.e.

$$A = A(T) \quad (3)$$

Where $A > 0$. The production function then looks like

$$Y = A(T) K^\alpha L^{1-\alpha} \quad (4)$$

This equation says that countries with a larger R&D stock have a higher level of total factor productivity; or, taking first differences, countries with higher R&D investments experience faster TFP growth. The relationship between R&D and TFP as expressed in equation (3) can reflect two effects: innovation and adoption. R&D is an essential factor in the innovation process, and R&D helps firms to build absorption capacity, i.e. the ability to exploit knowledge spillovers (cf. Cohen and Levinthal, 1989). This concept of absorption capacity captures the idea that one has to do basic research oneself in order to understand results of other researchers.

2. Empirical Relationship Between R&D and Economic Growth:

A) Returns to R&D:

There is by now a substantial literature on the impact of R&D on output. Cameron (1998) presents an overview of the empirical literature on the returns to R&D. The impact is often estimated to be quite high. A typical estimate of the social rate of return to R&D would be in the order of 20 to 30 percent when estimated at the industry level, and can be much higher economy-wide (Jones and Williams (1998) even mention an economy-wide social rate of return of around 100%). Estimated private returns to R&D are in the order of 7-14%. Discrepancies between marginal private and marginal social returns to R&D imply that the incentives for firms to invest in R&D are sub-optimal. Jones and Williams (1998) conclude that there is

substantial underinvestment in R&D: “optimal R&D spending as a share of GDP is more than two to four times larger than actual spending” (p. 1121).

However, empirical estimates of the returns to R&D are not undisputed. First, the estimates are subject to measurement errors. For example, econometric specifications do not allow making a distinction between intended and unintended spillovers, while only unintended spillovers are a market failure. In other words, knowledge flows which carry a market price and knowledge flows which are not priced cannot be distinguished in the statistics (cf. Cornet and Van de Ven, 2004). Second, estimates on the returns to R&D might be unreliable due to specification problems. For instance, Comin (2004) warns that there are many factors omitted in the typical regression that simultaneously affect TFP growth and the innovators’ incentives to invest in R&D, and mentions as the most obvious candidates anything that enhances disembodied productivity, like managerial and organizational practices. When these factors are ignored, the estimated returns to R&D are biased upwards. Comin pioneers an alternative approach in an attempt to overcome the difficulties that beset the econometric framework. He starts from the free-entry condition for innovators and the fact that most R&D innovations are embodied. Upon calibrating his model to US data he finds that the annual contribution of R&D to productivity growth is smaller than three to five tenths of one percentage point. His analysis implies that, if the innovation technology takes the form assumed in the literature, the actual US R&D intensity may be close to the socially optimal one.

b) R&D and Economic Growth:

Overviews of the literature on R&D and economic growth can be found in Cameron (1998) and Jones and Williams (1998). Here we confine ourselves to a study of Griffith *et al.* (2000, 2004) in which particular attention is paid to the ‘two faces’ of R&D (cf. Cohen and Levinthal, 1989). Griffith *et al.* investigate TFP convergence in a panel of industries across 13 OECD countries over the 1970-1990 periods. For each industry, the distance to the technological frontier is used as an indicator for potential technology transfer, where the technological frontier is defined by the country with the highest TFP in the corresponding industry. Adoption of technology is then reflected in international convergence of TFP-levels, also called catch-up growth. The direct effect of R&D shifts the technological frontier. The researchers find that both R&D and human capital are important for movements towards and shifts of the technological frontier. The authors present estimates of the total social return to R&D, and the return due to adoption / imitation. Being the technological leader in most industries, the returns to R&D in the USA are almost fully determined by the direct innovation-effect. The return to R&D from technology adoption is only 0.5%. Also for the Netherlands it is found that the innovation-effect is more important than the adoption-effect. Technology adoption is a major determinant of the social return to R&D for the Scandinavian countries, Italy, Japan, and the UK.

But in this paper we investigate the impact of R&D expenditure on economic growth in some developing countries. The literature suggests that roughly half of cross-country differences in per capita income and growth are driven by differences in Total Factor Productivity, generally associated with technological progress.

To date, the literature relative to developing countries is extremely thin. Lichtenberg (1994) works with a cross section of 53 countries and argues that the return to private R&D is seven times larger than to fixed investment. Coe, Helpman and Hoffmaister (1997) and a sub-sequent literature (Keller 2001) estimate the impact of foreign R&D on manufacturing TFP growth in developing countries. These authors argue that because developing countries own R&D expenditures are so low, they can be ignored. The data employed here suggest that developing-country R&D is not necessarily insignificant relative to the size of their economies, and more importantly, the returns are substantial. In fact, the returns to R&D in developing countries are above those for industrialized countries.

3. Model, Data, and Estimation Methodology:

We study the case of 30 countries from developing countries and use annual data for the 2000 - 2006 periods. This time period and frequency is largely dictated by the availability of data on R&D. Data on R&D expenditure, GDP, Investment (Gross fixed capital formation) and labor force in constant (2000 US \$) prices are from WDI, and UNESCO.

The basic model to be estimated on panel data for 30 developing countries is a simple Cobb-Douglas production function and the sample period is 2000-2006.

$$GDP_{it} = Exp(\alpha_i) GDP_{it-1}^{\beta_1} L_{it}^{\beta_2} K_{it}^{\beta_3} RD_{it}^{\beta_4} U_{it}^{\beta_5} \tag{5}$$

The variables (for country i and time t):

GDP is gross domestic production

L is labor force

K is gross fixed capital formation

RD is R&D expenditure

The model can be rewritten as follows:

$$\ln(GDP_{it}) = \alpha_i + \beta_1 \ln(GDP_{it-1}) + \beta_2 \ln(L_{it}) + \beta_3 \ln(K_{it}) + \beta_4 \ln(RD_{it}) + \varepsilon_{it} \quad (6)$$

We run the regression with use of panel data technique. Benefits of panel data are:

- They are more informative (more variability, less collinearity, more degrees of freedom), estimates are more efficient.
- They allow to study individual dynamics (e.g. separating age and cohort effects).
- They give information on the time-ordering of events.
- They allow to control for individual unobserved heterogeneity.

Panel data regression is very efficiency for extend estimation methods and theoretical result, as therefore researchers able to use of cross section and time series data for study issues that they can't investigate with cross section or time series data separately. The benefit of panel data is that traditional econometrics methods don't take account heterogeneous between units or groups therefore the results will face to bias risk.

As general a regression model of panel data is as follow:

$$Y_{it} = \alpha_{it} + \beta_1 X_{1it} + \beta_2 X_{2it} + \dots + U_{it} \quad U_i = \mu_i + v_{it} \quad (7)$$

Where $E(U_i) = 0$ and have constant variance. μ_i include fixed effects that show difference between individual, households or countries especial characteristic.

v_{it} is residual term that:

$$v_{it} \approx IND(0, \delta_7^4) \quad (8)$$

First we test heterogeneous between units by F-statistic. If null hypothesis isn't accepted, we use panel data. Null hypothesis is:

$$H_0 : \mu_1 = \mu_2 = \dots = \mu_N = 0$$

$$H_1 \neq H_0$$

$$F = \frac{(RRSS - URSS) / (N - 1)}{URSS / (NT - N - K)} \sim F_{[(N-1), (NT-N-K)]} \quad (9)$$

RRSS: Restrict Residual sum Squares

URSS: Unrestricted Residual sum Squares

N=numbers of units

K=numbers of parameters

Then for choice between Fixed Effect (F.E) and Random Effect (R.E) models we used Hausman Test:

$$H = (b_s - \beta_s)' (M_1 - M_0)^{-1} (b_s - \beta_s) \approx \chi^2(r) \quad (10)$$

Where r = numbers of parameters, M_1 = covariance matrix for coefficients of F.E model (b_s) ,

M_0 = covariance matrix for coefficients of R.E model (β_s)

In Hausman test null hypothesis show Fixed Effect. In according above tests we run the regression whit Random effect model (GLS method). Table 1 presents the GLS regression results

Table 1:

Dependent Variable: Ln (GDP _t)				
Method: GLS (Variance Components)				
Sample: 2000 2005				
Included observations: 6				
Total panel (balanced) observations 180				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.231272	0.064162	3.604515	0.0004
Ln (GDP _{t-1})	0.921455	0.012901	71.42556	0.0000
Ln (L)	0.006837	0.004798	1.425025	0.1559
Ln (K)	0.076145	0.011491	6.626518	0.0000
Ln (RD)	-0.005009	0.007676	-0.652560	0.5149
GLS Transformed Regression				
R-squared	0.999742	Mean dependent var		24.14787
Adjusted R-squared	0.999736	S.D. dependent var		1.841229
S.E. of regression	0.029929	Sum squared resid		0.156760
Durbin-Watson stat	1.687968			
Unweighted Statistic including Random Effects				
R-squared	0.999766	Mean dependent var		24.14787
Adjusted R-squared	0.999761	S.D. dependent var		1.841229
S.E. of regression	0.028484	Sum squared resid		0.141988
Durbin-Watson stat	1.863585			

Table 2: Coefficient Covariance Matrix

	C	Ln (GDP _{t-1})	Ln (L)	Ln (K)	Ln (RD)
C	0.004117	-0.00049	8.01E-05	-1.07E-06	0.00028
Ln (GDP _{t-1})	-0.00049	0.000166	-1.62E-05	-9.59E-05	-4.65E-05
Ln (L)	8.01E-05	-1.62E-05	2.30E-05	-4.98E-06	2.80E-06
Ln (K)	-1.07E-06	-9.59E-05	-4.98E-06	0.000132	-2.57E-05
Ln (RD)	0.00028	-4.65E-05	2.80E-06	-2.57E-05	5.89E-05

Table 3: Summary Statistics

	Ln (RD)	Ln (K)	Ln (L)	Ln (GDP _{t-1})	Ln (GDP _t)
23.447	22.666	15.5388	24.09437	24.14787	Mean
23.298	22.3888	15.2428	23.71977	23.74704	Median
28.5602	27.3532	20.4697	28.17043	28.26756	Maximum
19.178	19.1785	13.1798	20.6576	20.6681	Minimum
2.24249	1.83909	1.63921	1.848953	1.841229	Std. Dev.
180	180	180	180	180	Observations
30	30	30	30	30	Cross sections

Appendix. List of Countries

	Country Code	Country Name		Country Code	Country Name
1	ARG	Argentina	16	LVA	Latvia
2	ARM	Armenia	17	LTU	Lithuania
3	AZE	Azerbaijan	18	MUS	Mauritius
4	BLR	Belarus	19	MEX	Mexico
5	BRA	Brazil	20	MNG	Mongolia
6	BGR	Bulgaria	21	PAN	Panama
7	CHL	Chile	22	POL	Poland
8	CHN	China	23	ROM	Romania
9	HRV	Croatia	24	RUS	Russian Federation
10	CZE	Czech Republic	25	SVK	Slovak Republic
11	EST	Estonia	26	SDN	Sudan
12	GEO	Georgia	27	TTO	Trinidad and Tobago
13	HUN	Hungary	28	TUN	Tunisia
14	IRN	Iran, Islamic Rep.	29	TUR	Turkey
15	KGZ	Kyrgyz Republic	30	VEN	Venezuela, RB

4. Findings and Concluding Remark:

Based on regression results in table 1 the estimated parameters -except coefficient of R&D- in equation

(6) are significant. The elasticities of labor and gross fixed capital formation are positive and significant. But the R&D elasticity is negative and insignificant. The other words 1% increase in labor and investment increases economic growth about %0.007 and %0.08. But in general no significance positive impact exists in the countries under consideration.

In the context of developing economies such as Turkey, our findings suggest that in order to reach high economic growth, they should increase their R&D activities. Developed countries experience has shown that leader countries in innovation and R&D activities have higher economic growth than the others.

This paper's findings show that because of low R&D expenditure in developing countries the effect of this variable on economic growth was not significance. Thus governments in these countries should support R&D sector in institutions and industries.

REFERENCES

- Aghion, P. and P. Howitt, 1992. "A model of growth through creative destruction", *Econometrica*, 60(2): 323-351.
- Cameron, G., 1996. Innovation and economic growth, CEPR Discussion Paper 277, London.
- Canton, E., B. Minne, A. Nieuwenhuis, B. Smid and M. Van Der Steeg, 2005. "Human capital, R&D and competition in macroeconomic analysis", European Network of Economic Policy Research Institutes, Working Paper No. 38/August 2005.
- Chol-Won, L., 2003. "R&D-based Growth Models", Lectures at University of Zurich, Department of Economics University of Glasgow, pp: 1-58.
- Coe, D., E. Helpman and A. Hoffmaister, 1997. "North-south R&D spillovers", *Economic Journal*, 107: 134-149.
- Cohen, W.M. and D. Levinthal, 1989. "Innovation and learning: The two faces of R&D", *The Economic Journal*, 99: 569-596.
- Comin, D., 2004. "R&D: A small contribution to productivity growth", *Journal of Economic Growth*, 9: 391-421.
- Eurostat news releases on the Internet: <http://ec.europa.eu/eurostat>
- Griffith, R., 2000. How important is business R&D for economic growth and should the government subsidize it? Institute for Fiscal Studies Briefing Note 12, London.
- Griffith, R., R. Harrison and J. van Reenen, 2004. "How special is the special relationship? Using the impact of US R&D spillovers on UK firms as a test of technology sourcing", paper presented at an NBER meeting (<http://www.nber.org/confer/2004/si2004/prl/vanreenen.pdf>).
- International comparisons – OECD Main Science and Technology Indicators, 2008.
- Jones, C.I., 1995. "R&D-based models of economic growth", *Journal of Political Economy*, 103(4): 759-784.
- Keller, W., 1998. "Are international R&D spillovers trade related? Analysing spillovers among randomly matched trade partners", *European Economic Review*, 42: 1469-1481.
- Klaus, W. and W. Ulrich, 2004. "R&D expenditure in G7 countries and the implications for endogenous fluctuations and growth", *Economics Letters*, 82: 91-97.
- Lederman, D. and W. Maloney, 2003. "R&D and Development", Policy Research Working Paper, 3024.
- Levine, R. and D. Renelt, 1992. "A sensitivity analysis of cross-country growth regressions", *American Economic Review*, 82(4): 942-963.
- OECD, 2006. Main Science and Technology Indicators, OECD, Paris.
- Rajeev, K., J. Goel and R. Payne, 2008. "R&D expenditures and U.S. economic growth: A disaggregated approach", *Journal of Policy Modeling*, 30: 237-250.
- UNESCO Institute for Statistics S&T database, unless specified otherwise / Base de données S&T de l'Institute de statistique de l'Unesco, sauf indication contraire.