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Research Effort and Economic Growth*

W A Razzak
School of Economics and Finance, Massey University, PN, New Zealand

W A Razzak
Honorary Research Fellow
School of Economics and Finance
Massey University
Private Bag 11222
Palmerston North 4442
NEW ZEALAND
Email: razzakw@gmail.com

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W A Razzak

School of Economics and Finance, Massey University, PN, New Zealand

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Abstract

Total factor productivity growth (TFP) is positively related to the growth rate in effective research efforts. At the macro level, research effort is the nonlinear product of human capital and the number of people engaged in research activity. The rate of return on human capital is positive across the G7 countries. However, the rate of return on the number of researcher is negative in all countries except the U.S. thus; there is a decreasing return to scale in the production of new ideas.

JEL Classifications O40, O47

Keywords TFP Growth, Research Efforts, Education, Human Capital, Useful Knowledge

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[⋆] All correspondence to W A Razzak, School of Economics and Finance, Massey University, PN, New Zealand, email: razzakw@gmail.com and w.razzak@massey.ac.nz.

1. Introduction

The thesis of Simon Kuznets on economic growth in developed countries revolves, most importantly, on the process of producing *useful knowledge*. He says (italic is our emphasis) "…, many production plants in *developed countries* can be viewed as laboratories for the exploration of natural processes and as centers for research on new tools, both of which are of immense service to basic and applied research in science and technology. It is no accident that the last two centuries were also periods of enormous acceleration in the contribution to the stock of *useful knowledge* by basic and applied research – which provided additional stimulus to new technological innovations. Thus modern economic growth reflects an interrelation that sustains the high rate of advance through the feedback from mass applications to further knowledge."Kuznets (1973) Nobel Lecture.

Nelson and Phelps (1966) hypothesized that "educated people make good innovators, so that education speeds the process of technological diffusion," which leads to a higher growth. Modern endogenous growth models, e.g., Romer (1990), Aghion and Howitt (1992), Akcigit et al. (2016), Jones (2002), and Jones and Kim (2018 for examples, link total factor productivity growth (TFP) directly to research input.

Therefore, the product of research and education (human capital) are related to TPF directly. However, the puzzle is that TFP growth has been falling in developed countries and the number of people engaged in research has been increasing. Bloom et al. (2019) use micro data to argue that although the number of researchers and research intensity has increased, research productivity has declined, hence TFP growth declined. They suggest that ideas have become hard to find.[1]

We use macro data for the G7 countries from 2000 to 2017 to show that TFP and the effective research efforts growth rates are positively correlated as predicted by Simon Kuznets. To explain (the recent decline) productivity growth, we model TFP growth as a function of the growth rate of effective research efforts, whereby the level of the effective research effort is a nonlinear function of the product of number of researchers and the level of human capital. If TFP is viewed as "ideas" or "useful knowledge" then the production function of ideas and useful knowledge depends on two factor inputs, the number of researchers, and their level of human capital.

[1] See Feldstein (2017) argued that the decline in productivity is a mismeasurement problem.

We interpret the results as saying that research has been producing ideas, but not necessarily "useful" ones for increasing the production of *new* goods. Next, we present the model and the results. Section 3 is a summary.

2. The model and the results

TFP growth is a positive function of the growth rate of effective research efforts.

$$\dot{A}_{it} \cong \dot{H}_{it}, \tag{1}$$

where, $\dot{A}_{it}$is TFP, $\dot{H}_{it}$is the growth rate of effective research efforts, and i is country 1 to 7.

$$H_{it} = h_{it}^{\alpha_i} L_{it}^{\beta_i}, \tag{2}$$

where, H_{it} is the level of effective research efforts, $h_{it}$is the level of human capital, $L_{it}$is the number of people engaged in research, α and β are the rates of returns on human capital and the number of researchers. These parameters vary across countries, but we hypothesize that because education and average years of schooling in the G7 are similar, $\alpha_i$is the same for all G7 countries, but $\beta_i$is different reflecting different rates of productivity of research. We search for the values of $\alpha_i$and $\beta_i$that solves equations (1) and (2).

The data include human capital, which is an index reported by the Penn World Table 9.1, and based on average years of schooling. The number of researchers data are taken from the World Bank, and it measures the number of researchers engaged in Research &Development (R&D), expressed as per million. Researchers are professionals who conduct research and improve or develop concepts, theories, models techniques instrumentation, software of operational methods. R&D covers basic research, applied research, and experimental development. We use total population data to obtain the number of researchers. TFP growth is total economy TFP growth rate taken from the Conference Board.

Results

First, indeed, the growth rate in the numbers of researchers and TFP growth are uncorrelated. Figure (1) plots the cross sectional averages over the sample by country. The scatter plots are off the 45°line. There is no association between TFP growth and the growth rate of the number of researchers.

Second, table (1) reports the values of $\alpha_i$and β_i that solves the model. The rate of return on human capital is the same in Canada and Europe and the U.S., however, it is significantly higher in Japan and the U.K. The rate of return on research is negative except for the U.S. It

is negative and has the same value in Canada, Japan and the EU countries, and the U.K. The U.S. has the highest value. The sum of α_i and β_i is less than 1 in all countries, and negative in Italy. These results may suggest that doubling the effective research effort requires more than doubling human capital and the number of researcher, i.e., decreasing return to scale.

Figure (1)

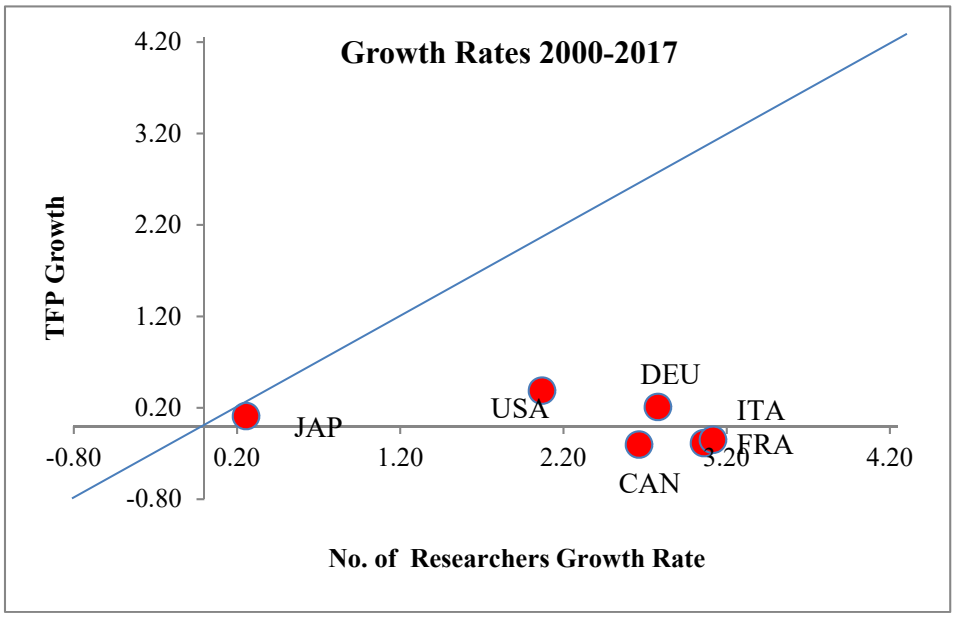


Table (1)
Total Economy Measures

	α_i	β_i	Sum
CANADA	0.10	-0.10	0.00
FRANCE	0.10	-0.09	0.01
GERMANY	0.10	-0.09	0.01
ITALY	0.10	-0.17	-0.07
JAPAN	0.40	-0.10	0.30
UK	0.30	-0.10	0.20
US	0.10	0.20	0.30

Third, the EUKLEMS data set includes data for TFP that exclude a number of sectors of the total economy, where output is hard to measure, Jäger (2017). They call this data the "market economy." Let $\dot{A}_{it}^{m}$ be the market economy TFP growth, where the superscript refers to the market measure. The market economy measure of TFP excludes the following sectors: real estate activity; public administration and defense; compulsory social security; education, health and social work; and activities of households as employers; undifferentiated goods – and services-producing activities of households for own use. This measure of TFP is more appropriate than the total economy TFP especially when research activity is more

concentrated in the production sectors. On average, $\dot{A}_{it}^{m}$ is higher than $\dot{A}_{it}$, except for France. Table (2) shows the differences.

Table (2)
TFP Growth

	$\dot{A}_{it}$	$\dot{A}_{it}^{m}$
France	0.07	0.01
Germany	0.49	0.58
Italy	-0.46	-0.44
U.K.	0.40	0.58
U.S.	0.46	0.62

Source: EUKLEMS

Table (3) reports the values of $\alpha_i^m$and β_i^mthat solve the model. The data are available for France, Germany, Italy, the U.K. and the U.S. only and from 2000 to 2015. The values of α_i change in France only; it decreased from 0.10 to 0.02. Earlier, we showed that TFP growth for France declined when using the market economy measure. The rate of return on research β_i increased substantially. For France, it increased from -0.1 to zero. For Germany, it increased significantly from -0.09 to 0.20. Italy's coefficient increased only slightly. For the U.K., the rate of return on research increased from -0.1 to 0.13. The sums of the rates of returns are still less than one, and negative in Italy. The U.S. had the highest coefficient before, and it increased here too.

Table 3
Market Economy TFP Data

	α_i^m	β_i^m	sum
FRANCE	0.02	0.00	0.02
GERMANY	0.10	0.20	0.30
ITALY	0.10	-0.13	-0.03
UK	0.30	0.13	0.43
US	0.10	0.25	0.35

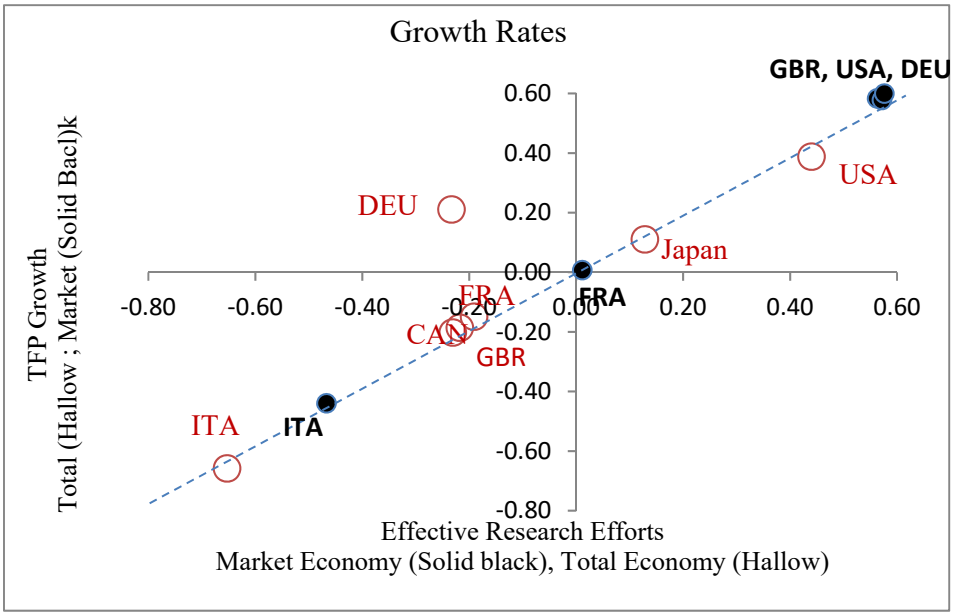
Figure (2) plots the data. The fit along the 45° line between TFP growth and the growth rate of the effective research efforts is perfect conditional on the values of the parameters α_i, β_i for the total economy TFP growth, and $\alpha_i^m$and β_i^m for the market economy measure .

3. Summary

We use data for the G7 countries to explain the recent decline in TFP growth rate. In the model, TFP growth is positively associated with the growth rate of the effective research efforts directly. The latter is a function of the product of human capital and the number of people engaged in research activity. The correlation is explained by a positive rate of return on human capital, which is nearly constant across the G7, and a negative varying rate of

return on research. We interpret this result as researchers have been producing ideas that are not useful knowledge for the production of goods.

Figure (2)



Data appendix

Human capital – source Penn World Table 9.1, the number of researchers are from the World Bank data set. Population is from the Penn World Table 9.1 to convert researcher per million people into absolute number of researchers. TFP growth rate is from the Conference Board. TFP market measure is from EUKLEMS.

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