ESTIMATING TOTAL FACTOR PRODUCTIVITY BY GROWTH ACCOUNTING AND GROWTH REGRESSION METHODS: EVIDENCE FROM SILK ROAD REGION

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Abstract - In the article, the growth of total factor productivity (TFP) is estimated for the panel data of 86 countries (and its various samples) located in the ancient Silk Road region for the period of 1991-2019 by growth accounting and growth regression methods. The findings are:
1) both growth accounting and growth regression methods produce the estimates of the TFP figures that are highly correlated with each other and reflect the technological progress of the countries
2) there are significant differences in TFP growth rates among different income level countries
3) in growth regression, due to existence of serial correlation and heteroscedasticity issues, the GLS model was preferred over Pooled OLS, Fixed Effect and Random Effect models
4) there is a consistency and robustness between our estimations of TFP levels and growth rates with those of other international databases such as Penn World Tables 10.0.

Keywords - total factor productivity, growth theory, growth accounting, growth regression, Pooled OLS, Fixed (Random) Effect, Generalized Least Squares.

I. INTRODUCTION

In growth economics, TFP shows the operational efficiency of a firm, industry or national economy. It is measured as the ratio of aggregate output to the aggregate inputs. NariyoshiOguchi[1, p.3] noted "Productivity growth is the key factor in economic development and sustained growth. There are various measures such as labor productivity, capital productivity, etc. Among them, TFP is a comprehensive measure of productivity and has gained acceptance as such among government officials, policy makers and productivity specialists and economists". TFP growth (also known as technological progress) depends on the discovery of the new or improved methods of producing goods; consequently, it reflects the multiple factors such as inventions and innovations, research and development, new technologies, economies of scale, managerial skills, the organization of production and others. Easterly and Levine [2] stated that even after physical and human capital accumulation are explained, something else (economists call it TFP) accounts for the bulk of cross-country differences in the level and growth rate of GDP per capita.

In 1957, Robert Solow introduced the concept of growth accounting, which is a quantitative tool to break down how specific factors (labor, capital and technology) contribute to economic growth. In his seminal work [3], Solow concluded that the long run economic growth is maintained by the technological progress rather than capital accumulation.

The proposals to restore the ancient Silk Road and to promote the economic integration of a great number of countries in almost all continents have been made since the end of the Cold War in 1990s. In 2011, US government proposed "American New Silk Road" project to promote economic ties and infrastructure development in Central and South Asia. In 2013, Chinese government proposed "Belt and Road Initiative" (known within China as the "One Belt One Road" or "Silk Road Economic Belt"), whose objectives are "to construct a unified large market and make full use of both international and domestic markets, through cultural exchange and integration, to enhance mutual understanding and trust of member nations, resulting in an innovative pattern of capital inflows, talent pools, and technology databases". In 2015, Russian government proposed to launch the "Eurasian Economic Union" to encourage the free movement of goods, services, capital and labor. While as of January 2023, 151 countries have signed up to the Belt and Road Initiative, yet there are different views on the initiatives of the great powers.

In 2019, the 86 countries [4] (Table 1 in Appendix) located in the ancient Silk Road region altogether constituted over 76% of the world population and over 68% of the world real GDP. The aim of this research article is to contribute to the existing body of research by measuring the TFP levels and growth rates for 86 Silk Road countries and comparing the sources of economic growth of the countries. To estimate the TFP growth, we will use both growth accounting and growth regression as Bosworth and Collins [5] argued that both growth accounting and growth regression are valuable tools for understanding the growth experiences across countries. They performed the analyses for 84 countries that together represent 95 percent of gross

world product and 84 percent of world population, over a period from 1960 to 2000.

II. DETAILS EXPERIMENTAL

2.1. Literature review

Haggai [6] argues that the "One Belt One Road" initiative has huge potential in promoting economic development in the participating regions. The initiative is posed to promote policy coordination, facilities, connectivity, unimpeded trade, financial integration, increased economic performance and productivity and people-to-people bonds. Peng et.al. [7]analyzed the green total factor productivity trend and its determinants for 35 countries along Silk Road over the timespan from 2008 to 2018 using panel regression analysis with DEA and found:

1) BRI countries have seen an increase in their overall levels of GTFP over time; 2) There are regional differences in the levels of GTFP, with higher efficiency in Western Asia and Central and Eastern Europe, and lower efficiency in Southeast and Central Asia; 3) The analysis of GTFP for countries in these regions shows that the efficiencies of most countries have been improving, with that of only a few countries have been decreasing; 4) By using regression analysis, we find that variables such as import, export, industrial structure, and urban affect the BRI countries with growing GTFP.

I. Growth accounting. Since seminal paper of Solow [3], the theory of growth accounting has developed greatly. Baier et.al. [8]examined the relative importance of the growth of physical and human capital and the growth of TFP using newly organized data on 145 countries that span more than one hundred years. They found the following average growth of output, inputs and TFP for nine regions:

Region	Output	Capital	Human capital	TFP
All countries	1.65	2.37	1.10	0.13
Western countries	1.62	1.99	0.86	0.40
Southern Europe	1.78	2.28	1.01	0.35
Central and Eastern Europe	2.12	3.41	1.61	-0.07
Newly industrialized countries	2.72	4.03	1.32	0.50
Asia	1.62	2.15	1.13	0.16
Middle East	1.19	4.76	2.10	-1.78
North Africa	2.16	2.73	1.52	0.25
Central and Southern Africa	0.44	2.91	1.09	-1.24
Latin America	1.63	2.32	0.95	0.22

Iradian[9] calculated the TFP for 27 transition countries (comprising 13 CIS, 3 Baltics, 5 Central European and 6 Southeast European) covering the 1991-2006 period. For comparison purposes, he also performed the growth accounting for several fast-growing economies, including Chile, China, Ireland, and South Korea. His conclusion was that the estimated TFP growth for the former Soviet Union Republics were higher than other fast-growing economies. Asian Productivity Organization [1]published a survey of TFP estimations for its selected member countries (China, India, Indonesia, Iran, Japan, Republic of Korea, Malaysia, Nepal, Philippines, Singapore, Thailand, and Vietnam). According to NariyoshiOguchi[1 p.7], in all the economies except for Indonesia and Philippines, the mean TFP growth was positive for the period from 1980 to 2000.

II. Growth regression. Since the seminal work of Denny et.al [10], the theory of growth regression has developed greatly. The researches in growth regression vary in their approaches (levels, data, periods, factors, models and other). Kim and Lau [11] used meta-production function to empirically estimate the sources of economic growth of the East Asian newly industrialized countries (Hong Kong, Singapore, South Korea and Taiwan) as well as the Group-of-Five industrialized countries (France, West Germany, Japan, the United Kingdom and the United States). They found that the most important source of growth of the first sample is capital accumulation (about 48-72%) and of the second sample is technical progress (about 46-71%). Ladu[12] analyzed the economic performance of a sample of 115 European regions of 12 countries (Austria, Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Spain, United Kingdom) over the period 1976-2000 by using Generalized Least Squares (GLS) model. The author found remarkable differences among regions in the technological progress. For example, the lowest TFP level was for Ionia Nisia (Greece, 0.25) and the highest levels were for Ile de France (France, 2.70) and Nordrhein (Germany, 2.56). The author also noted that the large discrepancies among regions in Europe have important implications for the economic policies of the European Union. In fact, the author expected that the labor productivity of a following region would catch up to the technological level of the leading region, however, the TFP estimates

exhibit the discrepancies persisted among the regions over the period considered.

Despite the significant amount of research on the economic and TFP growth of Silk Road countries, there is still a lack of understanding of the differences among countries due to various reasons:

1) Data limitation and missing data: many countries lack reliable and comprehensive data on input factors, which can affect the accuracy of TFP estimates. For example, Peng et al. [7] considered only 35 Silk Road countries. 2) Methodological limitation: TFP estimation methods may be limited by their assumptions and specifications, which can lead to biased or inaccurate estimates. Numerous research studies have employed a single method without adequately examining the robustness of the findings. 3) Regional diversity: regional economies may have unique characteristics such as culture, history, geography, natural resources, government structure, education system, demography, migration, etc. After the collapse of USSR in 1991, the post-Soviet countries started to transit from command economy to market economy. In order to gain a comprehensive understanding of the TFP of Silk Road countries, it is necessary to consider the significant impact of the colonial legacy of the PS countries

To address these research gaps, we need to explore the following questions:
1) How does TFP vary across Silk Road countries?
2) How does TFP contribute to overall economic growth in Silk Road countries?
3) What are the sources of TFP differences in various income level countries of Silk Road region?

To answer the questions above, we will set the research objectives:
1) Estimate the TFP levels and growth rates of 86 Silk Road countries over the period from 1991 to 2019 using the growth accounting and growth regression methods.
2) Decompose economic growth into its constituent parts (capital, labor, TFP).
3) Compare TFP growth across different countries to understand productivity dynamics.

2.2. Methodology and Data collection

We will consider the Solow growth model and Cobb-Douglas production function:

$$Y_{it} = A_{it}K_{it}^{\alpha}L_{it}^{1-\alpha}, \alpha \in (0,1)$$

whereY is output (real GDP), K is capital input, L is labor input and A is technological progress (or TFP), i is a country index, t is a time index, α is the capital share of output, $1-\alpha$ is the labor share of output.

We take total differential of Y and divide by Y to get 2 growth accounting formulas:

$$g_A = g_Y - \alpha g_K - (1-\alpha)g_L (1)$$
$$g_A = g_{Y/L} - \alpha g_{K/L} (2)$$

where$g_{Y/L} = g_Y - g_L$is output per worker growth.

Ahmad et. al. [13] suggested that the equation (2) can be treated as a simple regression model, in which the output per worker is regressed on a constant (g_A) and $g_{K/L}$, while the capital share of output (α) acts as a coefficient of capital per worker growth. Once the coefficient is estimated, we can compute the TFP growth using the equation (2). The limitation of this model is the assumption that all countries have the same production function and capital share of output. Ataev [14] assumed non-constant returns to scale production function, took logarithm from it and considered a multiple regression model to estimate the capital and labor shares of output for 58 countries in the Silk Road region.

We will use 4 TFP estimation methods (Pooled OLS, Random Effect, Fixed Effect and Generalized Least Squares) for 6 samples of countries (86 countries located on the ancient Silk Road, 34 high income countries, 20 upper-middle income countries, 26 lower-middle income countries, 6 low income countries and 15 post-soviet countries). The sample of 86 countries are given in Table 1. All tables and figures are given in the Appendix. Stata 14 is used for all calculations and constructions of tables and figures. The data for real GDP, capital stock, labor force and labor share of output are obtained from the PWT 10.0 [15].

III. RESULTS AND DISCUSSION

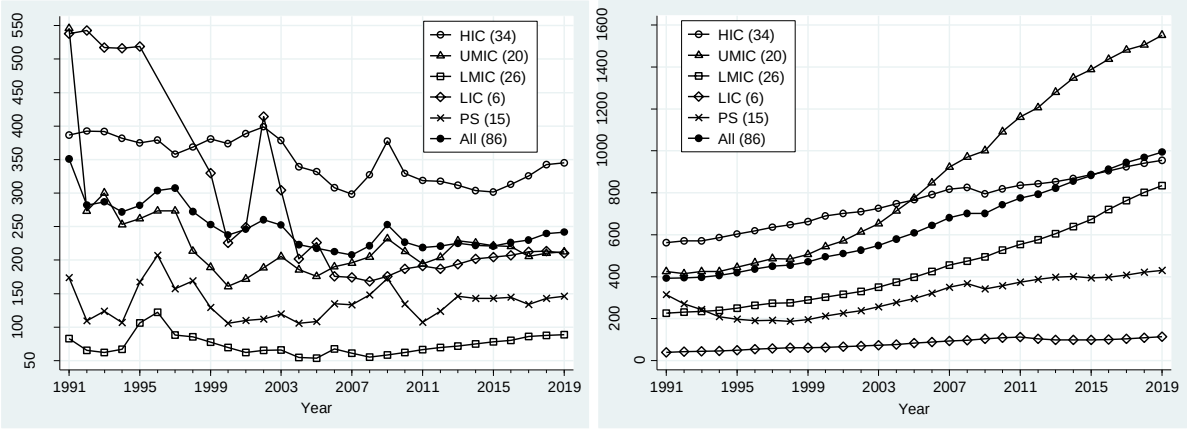


Fig. 1. Mean TFP levels (left) and mean real GDP (right)

I. Growth accounting. Fig.1 shows the mean TFP levels and outputs for each of six samples. In general, the output and TFP levels reflect the country's income status, that is, the higher the income status is, the higher the levels are, except for the TFP of LICs. The TFP levels of the 15 PS countries are between the TFP levels of UMICs and LMICs, because 3 of them are HICs, 8 are UMICs and 4 are LMICs. The TFP levels of LICs were very much volatile. We can observe the catch-up effect, when less developed countries grow faster than more developed countries due to adoption of their technologies and production methods. Indeed, the UMICs (e.g. China, Russia, Turkiye and others) outperformed the HICs after 2005. There was a significant decline of mean output for all countries in 2008-2009, which can be explained by the Global Financial Crisis. On the other hand, there was a significant rise in TFP levels during this period, which was partially due to a compensation and implementation of new business ideas and innovative technologies. However, the TFP decreased after 2009 for a number of reasons: reduction of investment in research and development, reduction in investment in physical and human capital, decline in demand for goods and services so the firms lost incentives to invest in productivity-raising methods.

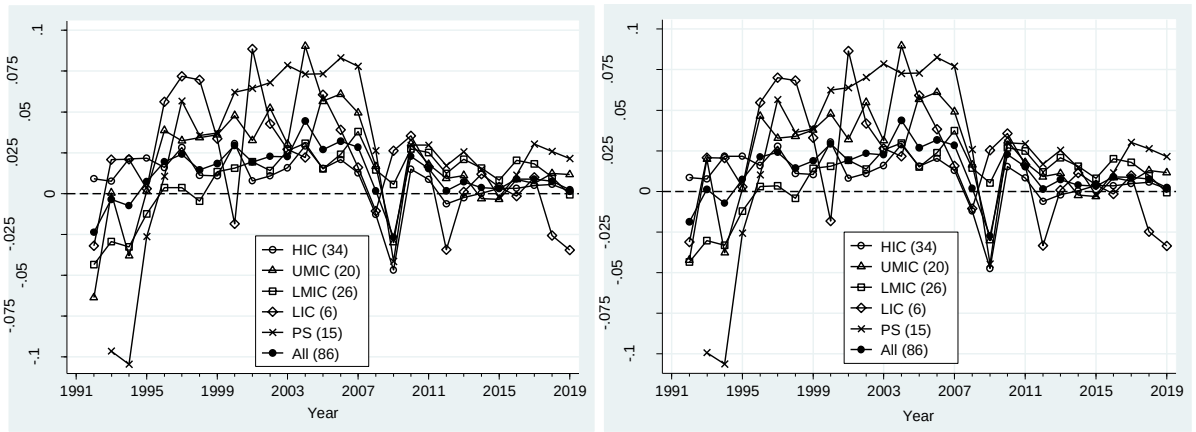


Fig. 2. Mean TFP growth by GA formula 1 (left) and GA formula 2 (right)

Fig. 2 illustrates the dynamic patterns in the mean TFP growth rates calculated by the growth accounting formulas (1) and (2). The two graphs exhibit almost the same movements with slight discrepancies due to different methodologies. For instance, the mean TFP growth rate for all 86 countries in 1992 was -2.38% by (1) and -1.86% by (2). HICs had the most stable growth rates. The PS countries had the lowest negative growth up to 1995; however, in general, they outperformed other samples of countries since 1997 for a number of reasons: 1) as mentioned above, PS countries are a combination of HICs and MICs. 2) developing countries attempt to catch up with developed countries, therefore grow faster. 3) PS countries transited from command economy to a market economy and benefited from trade openness, FDI, migration, tourism, spillover effect, educational, scientific, cultural, environmental and other structural reforms.

Islam [16] classifies the productivity determinants into four types:

1) economic factors: size of government, openness of the economy, investment in physical and human capital, infrastructure, competition, etc. 2) institutions: political stability, democratic rights, nature of legal system, property rights, governance, labor market regulations, education and training, etc. 3) social base: demographics, ethnic and religious composition of the population, colonial heritage, health, work and life balance, social mobility, civic engagement, etc. 4) physical base: location of a country, climate, access to sea, infrastructure, availability of natural resources, etc.

The PS countries have been reforming and implementing the progressive methods of production.

			1992-2000				2001-2010				2011-2019			
			K	**L**	**TFP**	**Y**	**K**	**L**	**TFP**	**Y**	**K**	**L**	**TFP**	**Y**
GA 1	34 HIC	Mean	1.21	0.20	1.74	3.20	1.84	0.60	0.68	3.09	1.40	0.68	0.20	2.26
		St. dev.	1.11	0.99	2.45	3.17	2.61	0.91	1.93	2.34	1.99	0.56	1.94	1.33
	20 UMIC	Mean	0.98	-0.28	0.99	1.75	2.01	0.25	3.90	6.08	2.06	0.51	1.96	3.54
		St. dev.	2.07	1.93	5.94	6.97	1.75	0.93	3.06	2.77	1.79	0.70	1.63	1.79
	26 LMIC	Mean	1.81	0.96	-0.96	2.96	2.44	1.05	2.15	5.95	2.66	0.80	1.45	5.08
		St. dev.	1.65	0.86	2.60	4.06	1.81	0.41	1.90	1.83	1.84	0.77	2.29	2.36
	6 LIC	Mean	1.26	2.03	2.51	5.33	2.63	1.21	3.47	5.95	3.92	1.32	-0.59	1.05
		St. dev.	0.35	1.48	2.14	1.80	0.75	0.39	0.68	2.26	4.37	0.19	3.04	7.23
	15 PS	Mean	-0.01	-1.02	-2.54	-3.44	1.09	0.14	5.33	6.64	1.43	0.29	1.93	3.95
		St. dev.	1.20	0.85	2.75	2.95	1.56	0.92	2.39	2.92	1.99	0.75	2.69	2.29
			K/L		TFP	Y/L	K/L		TFP	Y/L	K/L		TFP	Y/L
GA 2	34 HIC	Mean	0.91		1.73	2.44	0.64		0.69	1.03	0.46		0.22	0.65
		St. dev.	0.76		2.57	2.88	0.83		1.85	2.62	0.97		1.86	1.65
	20 UMIC	Mean	1.65		1.56	3.00	1.56		3.92	5.30	1.38		0.80	2.22
		St. dev.	2.77		7.23	7.86	1.63		3.09	3.34	1.45		2.26	2.04
	26 LMIC	Mean	0.77		-0.97	0.73	1.16		2.11	3.42	1.76		1.43	3.39
		St. dev.	1.36		2.60	3.10	1.76		1.86	2.19	1.72		2.24	2.34
	6 LIC	Mean	0.18		2.45	2.03	1.61		3.40	3.26	2.59		-0.56	-1.45
		St. dev.	0.01		2.09	1.68	0.40		0.67	2.49	3.68		2.97	5.91
	15 PS	Mean	0.92		-2.70	-1.93	0.88		5.29	6.07	1.04		1.92	3.15
		St. dev.	0.96		2.74	2.99	1.66		2.43	3.05	1.72		2.67	1.85

Table 2. Output growth decomposition. GA 1: $g_Y = g_A + \alpha g_K + (1-\alpha)g_L$. GA 2: $g_{Y/L} = g_A + \alpha g_{K/L}$.

Table 2 presents the output growth decomposition in three periods for different samples of countries. The growth accounting method of calculation of TFP growth is a residual, which is the portion of output growth that cannot be explained by the growth in capital and labor. It gives us a general idea about the magnitude of technological progress in a country. Therefore, the output of HICs increased on average by 3.2% per year in the 1990s, by 3.09% in the 2000s and by 2.26% in the 2010s. In fact, we can note many interesting and significant patterns:

1) in the 1990s, the mean TFP and output growth rates were higher for HICs compared with those of MICs and PS countries, however, in the next two periods it was the opposite. This can be explained by the catch-up effect of the developing countries. 2) in the entire period, the variations of TFP and output growth rates were lower for HICs compared with those of other categories of countries. It indicates the consistency and stability for HICs and the wider spread of the growth rates for other countries. 3) in the 1990s, the TFP contributed the most to the output growth of HICs, whereas the capital contribution was the largest for MICs and PS countries. In the 2000s, the capital contributed the most for HICs and LMICs, whereas the TFP was dominant for other samples of countries. In the 2010s, the capital contribution was the greatest for all countries except for PS countries, for which the TFP contribution was the biggest. The PS countries have been transiting from command economy to market economy and implementing a series of reforms; therefore the TFP has been the most contributing factor in the last two periods. Moreover, the negative growth rates of PS countries in the 1990s imply the challenges these countries encountered. 4) in the entire period, the labor contribution was the lowest for almost all countries. It is associated with such factors as technological advancement (automation, AI, etc.), globalization (relocation of labor), demography (aging population, declining birth rates, etc.), institutions (labor market regulations, minimum wage policies, etc.). 5) There are two types of economic growth: extensive (due to an increase in labor, capital, land, and natural resources) and intensive (due to an increase in efficiency or total factor productivity). For HICs, there was an intensive growth in 1990s and an extensive growth in the next two periods. For UMICs, there was an intensive growth in the first two periods

and extensive growth in the 2010s. For LMICs and LICs, there was an extensive growth in all three periods. For PS countries, there was an intensive decay in 1990s and an intensive growth in the next two periods.

Variables	Samples	n	Obs.	Mean	Std. dev.	Min	Max
Output per Worker growth	Total	86	2408	0.0223	0.0703	-0.3860	1.4217
	High income	34	952	0.0136	0.0493	-0.2989	0.9041
	Upper middle income	20	560	0.0357	0.1132	-0.3860	1.4217
	Lower middle income	26	728	0.0255	0.0457	-0.2682	0.1684
	Low income	6	168	0.0135	0.0652	-0.3338	0.1607
	Post-soviet	15	420	0.0256	0.0822	-0.3860	0.3285
Capital per Worker growth	Total	86	2408	0.0232	0.0580	-0.4724	1.6179
	High income	34	952	0.0128	0.0282	-0.1248	0.1663
	Upper middle income	20	560	0.0316	0.0980	-0.4724	1.6179
	Lower middle income	26	728	0.0310	0.0458	-0.1202	0.2712
	Low income	6	168	0.0202	0.0399	-0.0636	0.1504
	Post-soviet	15	420	0.0188	0.0406	-0.1150	0.2501

Table 3. Descriptive statistics

II. Growth regression. Table 3 provides the descriptive statistics of dependent variable (output per worker growth) and independent variable (capital per worker growth). We note that HICs have lower growth rates and variations compared to MICs and PS countries.

	All (86)	HIC (34)	UMIC (20)	LMIC (26)	LIC (6)	PS (15)
Capital per Worker growth (α)	0.6684*** (0.0166)	0.3993*** (0.0331)	0.7846*** (0.0257)	0.6539*** (0.0258)	0.5785*** (0.1038)	0.2060*** (0.0832)
p-value (F-test)	0.000	0.000	0.000	0.000	0.000	0.013
n	2408	952	560	728	168	420
Note:∗ p < 10%, ∗∗ p < 5%, ∗∗∗ p < 1%. Stan. Errors in brackest. Dep.Var.: Output per worker growth						

Table 4. Regression results. GLS is the model selected.

Tables 4 exhibits the results of regression analyses by four models (Pooled OLS, Fixed Effect, Random Effect and Generalized Least Squares) and GLS model was the most preferred based on the significance of serial correlation and heteroscedasticity tests.

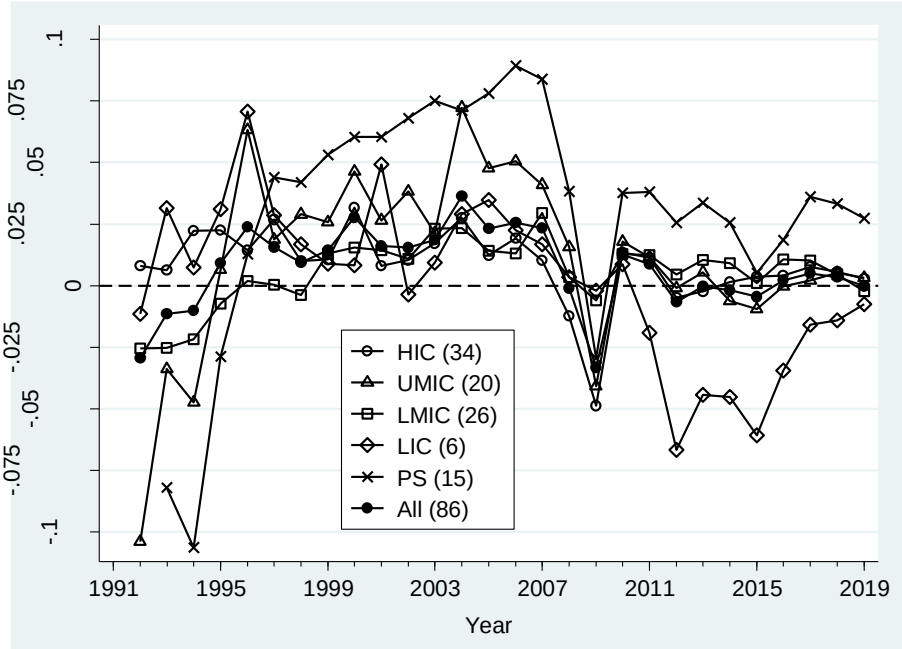


Fig. 3. Mean TFP growth by regression.

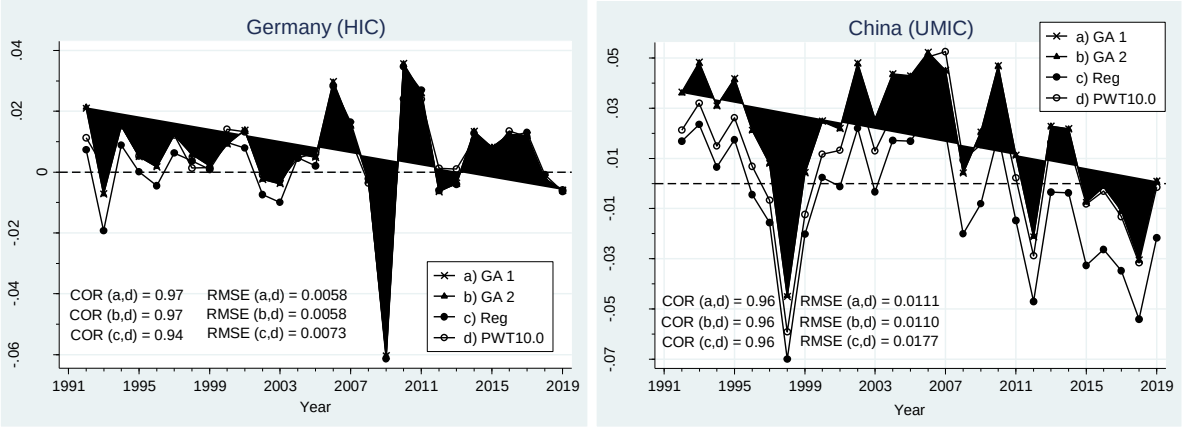


Fig. 4. TFP estimations for selected countries. COR – correlation, RMSE – root mean square error.

Fig. 3 illustrates the dynamic patterns in the mean TFP growth rates calculated by the growth regression method. Apparently, the small discrepancy between the results of growth accounting and growth regression is due to different methodologies. In 1992, both growth methods indicated the growth for only HICs. In 2019, both methods indicated growth for all samples except LMICs and LICs. However, for the total sample of 86 countries, the growth accounting indicated 0.24% growth and the growth regression indicated 0.0032% decline. Nevertheless, the two methods exhibit significantly close results, which we can observe in Fig. 4. It shows the comparison and accuracy of the TFP estimations given in the PWT 10.0 database and obtained in this research article. The high correlations (over 90%) with and low deviations (below 1.8%) from the PWT 10.0 estimations indicate that our TFP estimations computed by two different methods (accounting and regression) are sufficiently consistent and robust.

IV. CONCLUSION

The TFP growth of various samples of countries situated in the ancient Silk Road region is estimated for 1991-2019 based on two methods: growth accounting and growth regression. Our findings shed light on the technological progress of the countries in the region. The main findings are:

1) There is a significant contribution of TFP growth to economic growth for almost all economies.
2) There are significant differences in TFP growth rates among different income level countries.
3) There is a consistency between our estimations of TFP levels and growth rates with those of other international databases such as PWT 10.0.
4) Both growth accounting and regression methods prove efficient in estimating the TFP growth.

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REFERENCE

[1] Asian Productivity Organization.“Total Factor Productivity Growth: Survey Report”. 1-2-10 Hirakawacho, Chiyoda-ku, Tokyo 102-0093, Japan. 2004.

[2] Easterly W., Levine R. “What have we learned from a decade of empirical research on growth? It's Not Factor Accumulation: Stylized Facts and Growth Models”. The World Bank Economic Review, 15(2), 177–219. DOI:10.1093/wber/15.2.177. 2001.

[3] Solow, R. M. “Technical Change and the Aggregate Production Function”. Review of Economics and Statistics, 39(3), 312-20. 1957.

[4] World Bank. Retrieved on October 23, 2022, from https://databankfiles.worldbank.org/data/download/site-content/CLASS.xlsx

[5] Bosworth B.P., Collins S.M. “The Empirics of Growth: An Update. Brookings Papers on Economic Activity”. Vol. 34, Issue 2, 113-206. 2003.

[6] Haggai K. “One Belt One Road Strategy in China and Economic Development in the Concerning Countries”. World Journal of Social Sciences and Humanities, vol. 2, no. 1: 10-14. DOI:10.12691/wjssh-2-1-2. 2016.

[7] Peng Y., Chen Zh., Xu J., Lee J. “Analysis of green total factor productivity trend and its determinants for the countries along silk roads. Growth and Change”. 51(4). pp.1711-1726. 2020.

[8] Baier S. L., Gerald P. D. Jr., Tamura R. “How important are capital and total factor productivity for economic growth?” Working Paper, No. 2002-2a, Federal Reserve Bank of Atlanta. 2002.

[9] Iradian G. “Rapid Growth in Transition Economies: Growth-Accounting Approach”. IMF Working Paper. WP/07/164. 2007.

[10] Denny M., Fuss M., Waverman L. “The measurement and interpretation of total factor productivity in regulated industries with an application to Canadian telecommunications”. In T. G. Cowing, & R. E. Stevenson (Eds.), Productivity measurement in regulated industries. pp.179-218. New York: Academic Press. 1981.

[11] Kim J.I., Lau L.J. “The Sources of Economic Growth of the East Asian Newly Industrialized Countries. Journal of the Japanese and International Economies”, 8(3), 235-271. 1994.

[12] Ladu M.G. “Total factor productivity estimates: some evidence from European regions”. WIFO Working papers, No 380. Austrian Institute of Economic Research (WIFO), Vienna. 2010.

[13] Ahmad H. Kh., Ilyas M., Mahmood T., Afzal M. “Exploring the effect of total factor productivity growth on future output growth: Evidence from a Panel of East Asian Countries”. Pakistan Economic and Social Review, 48(1), 105-122. DOI:10.2307/41762416. 2010.

[14] Ataev F. “Estimating the total factor productivity: Evidence from the Great Silk Road region”.

Iqtisodiyotvainnovatsiontexnologiyalar (Economics and innovative technologies), 10(6), 167–182. DOI:10.55439/EIT/vol10_iss6/a18. 2022.

[15] Feenstra, Robert C., Robert Inklaar and Marcel P. Timmer. "The Next Generation of the Penn World Table". American Economic Review, 105(10), 3150-3182, available for download at www.ggdc.net/pwt. 2015.

[16] Islam N."Determinants of Productivity: A Two-Stage Analysis". International Centre for the Study of East Asian Development Working Paper Series, Vol. 13. 2005.

APPENDIX

1991	2019
20 Low income ($635 or less) Bangladesh, Bhutan, Cambodia, China, Egypt, Ethiopia, India, Indonesia, Kenya, Lao PDR, Madagascar, Mozambique, Myanmar, Nepal, Pakistan, Sri Lanka, Sudan, Tanzania, Viet Nam, Yemen 27 Lower middle-income ($636 to $2,555) Albania, Algeria, Armenia, Azerbaijan, Bulgaria, Djibouti, Georgia, Iran, Iraq, Jordan, Kazakhstan, Kyrgyzstan, Lebanon, Malaysia, Moldova, Mongolia, Morocco, Philippines, Poland, Romania, Syria, Tajikistan, Thailand, Tunisia, Turkmenistan, Ukraine, Uzbekistan 12 Upper middle-income ($2,556 to $7,910) Bahrain, Belarus, Estonia, Greece, Hungary, Republic of Korea, Latvia, Lithuania, Oman, Portugal, Russian Federation, Saudi Arabia 18 High-income ($7,911 or more) Austria, Belgium, Brunei Darussalam, Denmark, France, Germany, Israel, Italy, Japan, Kuwait,Luxembourg, Netherlands, Qatar, Singapore, Spain, Switzerland, United Arab Emirates, United Kingdom	7 Low income ($1,035 or less) Ethiopia, Madagascar, Mozambique, Sudan, Syria, Tajikistan, Yemen 23 Lower middle-income ($1,036 to $4,045) Algeria, Bangladesh, Bhutan, Cambodia, Djibouti, Egypt, India, Kenya, Kyrgyzstan, Lao PDR, Moldova, Mongolia, Morocco, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Tanzania, Tunisia, Ukraine, Uzbekistan, Viet Nam 22 Upper middle-income ($4,046 to $12,535) Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, China, Georgia, Indonesia, Iran, Iraq, Jordan, Kazakhstan, Lebanon, Malaysia, Montenegro, North Macedonia, Russian Federation, Serbia, Thailand, Turkiye, Turkmenistan 34 High-income ($12,535 or more) Austria, Bahrain, Belgium, Brunei Darussalam, Croatia, Czech Republic, Denmark, Estonia, France, Germany, Greece, Hungary, Israel, Italy, Japan, Kuwait, Latvia, Lithuania, Luxembourg, Netherlands, Oman, Poland, Portugal, Qatar, Republic of Korea, Romania, Saudi Arabia, Singapore, Slovakia, Slovenia, Spain, Switzerland, United Arab Emirates, United Kingdom

Table 1. List of countries in samples (based on GNI per capita in US dollar, World Bank)

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