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ESTIMATING THE TOTAL FACTOR PRODUCTIVITY: EVIDENCE FROM THE GREAT SILK ROAD REGION

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Abstract
In the paper the levels of total factor productivity (TFP) are estimated for the panel data of 58 countries located on the ancient Great Silk Road for the period of 1991-2019 with Pooled OLS, Random Effect and Fixed Effect models. The findings are:
1) Random Effect model was the most suitable model, although the three models produced approximately the same estimates of parameters
2) when the total sample of 58 countries was split into two samples of 19 developed and 39 developing countries and the three models were applied for the smaller samples, the models were not significant due to multicollinearity issue
3) the output elasticities of capital and labor comply with the figures ($\alpha \approx 0.7$ and $\beta \approx 0.3$) obtained in many empirical studies
4) in the sample of 10 post-soviet countries, the TFP figures are strongly correlated in 1991-2001 except for Armenia and in 1991-2019 except for Uzbekistan
5) Spearman's rank correlation test indicates a strong positive relation between the estimated total factor productivity and foreign direct investment for most post-soviet countries.
Keywords: Total factor productivity (TFP), growth theory, Pooled OLS, Fixed Effect, Random Effect, foreign direct investment (FDI)

Introduction

In 1956 and 1957 the professor Robert M. Solow at MIT published two research articles, one on a steady state growth and the other on the technical change in aggregate production function. In 1987 he was awarded the Nobel Memorial Prize in Economic Sciences for his contribution to the theory of long-term macroeconomic growth. His revolutionary articles shaped the Solow growth model. In his interview (Keegan, 2007) Professor Solow stated the motivation for his research: "10 years after the end of the war (WWII). And one of the great phenomena in the world is the fact that after a lot of post-war hassle, the European economies are beginning to grow rapidly… how to provide an explanation of the growth paths of a modern economy, and why some grow faster than others?" According to the Solow growth model, the economic growth or the change in the level of output in an economy over time results from the changes in labor, capital and technology (also known as knowledge, idea, innovation).

Measuring the changes in labor and capital is traceable, but measuring the technological progress is difficult to trace. Solow (1957) considered the aggregate output function of US for the period 1909-1949 and argued that one-eighth of the total increase was traceable to increased capital per man hour, and the remaining seven-eighth to technical change. Note that Solow (1957) calls the factor A as "technical change" as a shorthand expression for any kind of shift in the production function. It is this determinant that has remained "black box" for several decades. The growth in total factor productivity is known as Solow residual and much research has been done to decode and explain it: knowledge (Romer, 1986), human capital or education (Barro, 1991), innovations or patents (Aghion, 1992), research and development (Barro and Salai-Martin, 1995, Coe, 1995), national entrepreneurial ecosystem (Acs et.al, 2014) and others. In various other literatures, e.g., Sims (2018), one can see the factors such as climate, geography, institutions (stable government, the rule of law, property protection, stable social norms, etc.), finance (financial system), infrastructure (roads, running water, electricity, etc.), free trade and others.

Historically, there was a system of caravan routes known as the Great Silk Road that has existed for thousands of years and passed through many lands (over 50 countries today). It has been playing a pivotal role in sharing ideological and material goods, scientific ideas and technologies, cultural and religious values among Europe, Asia and Africa. The Great Silk Road was formally originated in 130BCE in China, and it was not just a single route, but a series of routes that connected the East with the West. When the sea routes were opened in the 15th century, the influence of the Great Silk Road has decreased for certain period. Nevertheless, there have been several projects to revive the Great Silk Road. To state some, the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) has proposed to restore a trans-Asian highway and a railway counterpart of the road. The ESCAP is one of the five regional commissions of the UN and it promotes cooperation among its 53 member states and 9 associate members in pursuit of solutions to sustainable development challenges. In 2013 Chinese government initiated a global infrastructure development strategy named "Belt and Road Initiative" (formerly known as "One Belt One Road" and "Silk Road Economic Belt"). The project aims at investing in nearly 150 countries and international organizations and building railroads, roads, bridges, seaports, airports, tunnels, dams, power stations and many more. It is believed that the project will boost the global GDP.

After the collapse of the USSR in 1991, several Turkic states such as Uzbekistan, Azerbaijan, Kazakhstan, Kyrgyzstan and Turkmenistan gained independence and started to transit from the command economy to market economy. In 2009, four Turkic states (Azerbaijan, Kazakhstan, Kyrgyzstan and Turkey) founded the Organization of Turkic States (then called Cooperation Council of Turkic Speaking States – Turkic Council). In October 2019, Uzbekistan joined as a full member. In November 2021, Turkmenistan joined as an observer member. One of the main goals of the organization is to strengthen peace and stability, promote wide-ranging cooperation and disclose the potential for common development among its member states. Certainly, one important aspect of common development is the economic cooperation. Situated at the heart of the Great Silk Road, the Turkic states could and should promote trade and cultural ties between the East with the West.

In order to realize and estimate the potential of the restored Great Silk Road, it is necessary to analyze and understand political, economic and social conditions in the member countries. The UNESCO's Silk Roads Programme (Silk Roads Programme, n.d.) provides essential information for 50 countries and the United Nation World Tourism Organization (UNWTO) provides the list of 35 Silk Road Member States. Hence, the present research is aimed at evaluating the sources of economic growth, in particular, the technological progress in these countries. The analysis of the technological progress will be carried out with the aid of Solow's growth model. Various econometric models will be tested to estimate the economic growth and the total factor productivity for the countries located on the ancient Great Silk Road for the period of 1991-2019. The estimation of the total factor productivity and determination of its main factors has both scientific and practical values.

Literature review

Alwyn (1992, 1995) examined four East Asian countries (Hong Kong, Singapore, South Korea, Taiwan) and found that the high rates of output growth were mainly due to high rates of factor accumulation and little due to technological progress. His research suggests that over the past two and a half decades, productivity growth in the aggregate nonagricultural economy of the four countries ranges from a low of 0.2% in Singapore to a high of 2.3% in Hong Kong, whereas in manufacturing productivity growth ranges from a low of -1.0% in Singapore to a high of 3.0% in South Korea. Costello (1993) studied Solow residuals (total factor productivity) for 1960-1985 for five manufacturing industries (food, textiles, chemicals, basic metals, and metal manufacturing) in six countries (USA, Canada, Japan, UK, Germany and Italy). He found that aggregate output growth was correlated across countries, but aggregate productivity growth was only weakly correlated across countries. He also found that the productivity growth was significantly correlated across industries within a country but was less correlated across countries for any individual industry. Sarel (1995) examined the different researches conducted about the East Asian growth experience, in particular, he focused on four areas: 1) the nature of economic growth intensive or extensive? 2) the role of public policy and of selective interventions. 3) the role of high investment rates and a strong export orientation as possible engines of growth. 4) the importance of initial conditions and their relevance for policy. Marrocu et. al. (2000) estimated a production function for 20 regions and 17 sectors in Italy over the period 1970-1994. They found that factor elasticities highly differed across regions and sectors. Michaelides (2009) estimated total factor productivity change for the Russian economy for 1994-2006 and found that despite the severe economic crisis TFP had contributed to strong economic growth in the country after 1998. Ladu (2010) computed TFP using a panel cointegration approach for 115 European regions over the period 1976-2000. Brock (2010) analyzed the macroeconomic growth across the 11 federal districts in Russia for 1995-2003. He found that poorer regions may converge to richer regions and suggested that domestic and foreign investment across Russia would enhance growth in the future.

While many research papers have found the Solow residual to be a good estimator of the technological progress, yet there are papers that are skeptical about it. For instance, Nelson (1971) argued that "the neo-classical theory is a way of looking at things than a real theory, and that neo-classical spectacles may distort or block perception of phenomena that should be at

the center of a serious theory of economic growth." Hartley (2010) claimed that the Solow residual could not measure the technological change and there were contradictory relations between the two in terms of direction and magnitude. He considered a simplified model with a single type of labor, a single type of capital and a single type of good. He also considered two means of producing capital: a fast, resource intensive method and a slow, less intensive method. And he showed that the Solow residual was a poor measure of technological change. Felipe and McCombie (2020) considered the calculation of TFP as illusive and concluded that the growth literature had to evolve and abandon the conceptualization of growth through a production function and through the TFP research program.

Note that the Solow growth model has several assumptions under which the Solow residual could be a good measure of the technological change. To state some: capital is subject to diminishing returns in a closed economy; the production function ought to be homogenous of the first degree; the two factors of production (labor and capital) are paid according to their marginal productivities; prices and wages are flexible; full employment of labor as well as capital; labor and capital are mutually substitutable; there is neutral technical progress, the saving ratio is constant. Also, the Solow growth model is more applicable to a long-run economic growth rather than short-run.

Saliola et. al. (2011) analyzed micro level data (at least 100 firms) from manufacturing industries in 80 developing countries and measured TFP performance at the firm-level as well as industry-level. The values of the aggregate TFP were estimated for 2008-2009 for Uzbekistan (0.64%), Kyrgyzstan (0.50%), Turkey (0.24%) and Kazakhstan (0.18%) on a firm-level. Arazmuradov et. al. (2014) investigated the process of GDP generation in 15 former Soviet Union economies over the period of 1995-2008. The researchers found that foreign direct investment and human capital improve countries' technical efficiency and have positive impact on total factor productivity. Turganbayev (2017) examined total factor productivity convergence across the regions of Kazakhstan for 1997-2013 and found that the average level of TFP fell by almost 40%. Nagshpour (2019) analyzed the determinants of economic growth for the newly formed countries of the former Soviet Union and identified contributing factors such as human capital, economic freedom and financial developments. Wang (2020) used Solow residual method to measure the contribution rate of technological progress to economic growth for the four China's first-tier cities in Beijing, Shanghai, Guangzhou and Shenzhen from 1992 to 2017 and found strong dependence of economic growth on the technological progress. Yormirzaev et. al. (2020) explored economic performance of CIS countries for the period from 1993 to 2016 and found TFP growth rates for Uzbekistan (1.15%), Azerbaijan (-0.61%), Kazakhstan (-0.17%), Kyrgyzstan (-2.17%) and Turkmenistan (-1.83%). Noman (2020) found that political institutions have a critical role in explaining economic growth of selected South Asian economies. Wu (2020) examined 46 countries included in the "Belt and Road" initiative for the period of 2003-2016 and found that China's outward direct investment significantly improves their green total factor productivity, a comprehensive index for environmental quality and productivity. Silveira et. al (2021) considered four TFP calculation methods (Olley and Pakes (1996), Levinsohn and Petrin (2003), Wooldridge (2009) and Ackerberg, Caves and Frazer (2015)) and used energy proxy in addition to capital and labor explanatory variables. They used

three samples (124 countries, developed and developing countries) for the period of 1995-2015.

Methodology and Data collection

We will consider the Cobb-Douglas production function:

$$Y_{it} = A_{it} K_{it}^{\alpha} L_{it}^{\beta} \epsilon_{it} \qquad (1)$$

where Y is aggregate output (real GDP), K is capital input (capital stock), L is labor input (number of employed people) and A is technological progress (or total factor productivity or Solow residual), i is a country index, t is a time index. Taking natural logarithm from the equation (1) we get the multiple linear regression model:

$$\ln Y_{it} = \ln A_{it} + \alpha \ln K_{it} + \beta \ln L_{it} + \ln \epsilon_{it} \qquad (2)$$

where Y, K, L are observable and A is unobservable. Once the regression is performed and α and β are estimated, the total factor productivity is calculated by the formula:

$$A_{it} = \frac{Y_{it}}{K_{it}^{\alpha} L_{it}^{\beta}} \qquad (3)$$

The data for real GDP, capital stock and labor force are obtained from the Penn World Table 10.0 (Feenstra e. al., 2015):

Description of the dependent and independent variables:

RGDPNA (dependent) – Real GDP at constant 2017 national prices (in mil. 2017US$)

RNNA (independent) – Capital stock at constant 2017 national prices (in mil. 2017US$)

EMP (independent) – Number of persons engaged (in millions)

Note that compared to other databases, such as the World Bank's World Development Indicators, the time period covered in this database is larger and there is more data that is useful for comparing productivity across countries and over time.

The data for the foreign direct investment are obtained from the United Nations Conference on Trade and Development (UNCTAD).

We will use 3 TFP calculation methods (Pooled OLS, Random Effect and Fixed Effect) for 3 samples of countries (58 countries located on the ancient Great Silk Road, 19 developed and 39 developing countries). The countries are classified into developed and developing based on Gross National Income per Capita by the World Bank (World Bank). The samples are given in Table 1. All tables and figures are given in the Appendix.

Stata 14 is used for all calculations. Microsoft Excel is used to construct the figures.

Results and Discussions

The formula (3) above shows that the total factor productivity is positively related with the real GDP and negatively related with the capital stock and labor force.

Table 2 presents descriptive statistics for all countries ($n = 58$) and for samples of developed countries ($n = 19$) and developing countries ($n = 39$).

Table 3 provides the correlation of variables (Pearson's correlation test). The independent variables Capital and Labor are strongly correlated with the dependent variable GDP in all samples. However, the independent variables are moderately correlated with each other in total sample and highly correlated in other two samples. High correlation causes the multicollinearity issue. Silveira et. al. (2021) also obtained the multicollinearity issue for the groups of developed and developing countries. As a result of this issue, the estimators lose their

precision, and the model is not robust. Therefore, they calculated TFP figures based on the total sample of 124 countries only. Thus, we will also consider the total sample of 58 countries only.

In Table 4 we can observe that the three models are all significant at 1% and produce almost the same results. However, Breusch-Pagan test shows the Fixed/Random Effect model is better than Pooled OLS model and Hausman test shows the Random Effect model is preferred over the Fixed Effect model. The estimated population parameters $\alpha \approx 0.70$ and $\beta \approx 0.29$ are significant at 1%. The output elasticity of capital $\alpha = 0.70$ indicates that one percent increase in capital results in 0.70 percent increase in production. Similarly, the output elasticity of labor $\beta = 0.29$ indicates that one percent increase in labor results in 0.29 percent increase in production. The R-squared value of 0.93 shows that the 93% variation in output can be explained by the capital and labor inputs.

The production function has almost constant return to scale, because the sum of output elasticities of capital and labor is approximately equal to 1. It implies if the capital and labor are increased t times, the output will also increase t times.

From Table 5 we can observe the mean TFP figures were quite high for mainly oil and gas exporting countries such as Arab countries and Azerbaijan. The mean TFP figures were quite low especially for countries involved in war such as Tajikistan (civil war in 1992-1997), Ukraine (since 2014), Georgia (civil war in 1991-1993, war in 2008), Albania (civil war in 1997, war in 1999), Yemen (civil war since 2014) and others. The start of the civil war in Syria in 2011 made the TFP figure to gradually decrease from 19.5 to 14.3 in 2012, 10.7 in 2013, 9.2 in 2014, 8.8 in 2015 and hit the lowest level of 8.4 in 2017. The low TFP figures for a series of countries such as former USSR countries, Albania, Croatia, Mongolia, Vietnam, China and others is associated with their transition from a centrally planned economy to a market economy. For example, if we look at the sample of 10 post-soviet countries in Figure 2 (see Appendix), we can observe that the TFP figures of almost all countries declined from 1991 to 1996. The main reason for this pattern is the transition of the economies. Also, Table 7 and Figure 2 indicate that the TFP figures are strongly correlated in 1991-2001 except for Armenia and in 1991-2019 except for Uzbekistan. TFP figures of most countries started to rise after 1996-1998, while Uzbekistan's TFP figures stayed almost stable from 1996 to 2003.

During the Soviet Union period all the member countries had strong interdependence in supply of intermediate goods. Although the USSR was the second largest economy in the world after the USA until 1988, when Japan replaced it, most economies of the member states were focused on the supply of raw materials and intermediate goods. The private business was totally prohibited by law until late 1980s (the period of perestroika – reconstruction), which discouraged people from taking initiative and innovative approaches in production and it contributed significantly to the gradual decline of economy of the USSR. In fact, in 1994 the European Bank for Reconstruction and Development (EBRD) developed a set of indicators to measure the progress in transition and provided brief descriptions of progress of transition economies, in particular, of post-soviet countries. Basically, the time period and depth of the reforms in the economies determined the future dynamics of the total factor productivity. Based on the mean TFP figures for the post-soviet countries (see Table 5), we can see only Azerbaijan (12.93), Uzbekistan (10.97) and Kazakhstan (10.40) scored higher than total sample

mean of 9.13, which should point to the success of the economic reforms and technological progress of the countries. In fact, the EBRD's 2017-2018 report also confirms the positive relation between the transition scores and the TFP figures of the countries (see Table 6). The countries such as Tajikistan, Ukraine, Turkmenistan, Kyrgyzstan, Albania and others with three or more low transition scores had low TFP figures. Whereas the countries such as Azerbaijan, Bulgaria, Jordan, Kazakhstan, Turkey and others with three or more high transition scores had high TFP figures. However, there are exceptional cases such as Egypt and Uzbekistan, whose transition scores are relatively low, yet TFP figures are relatively high. In order to understand this phenomenon, we need to consider the determinants of TFP. Silveira et. al (2021) gave a list of determinants from various research articles: research and development, infrastructure, financial system, location of the region, human capital, physical capital, exports, imports, foreign direct investment, inflation, unemployment rate, liquidity, etc. For example, Zidouemba, P.R. and Elitcha, K. (2018) found that the effect of foreign direct investment (FDI) on TFP growth is positive but decreases with the natural resource rents. In other words, the net effect of FDI on TFP growth differs across countries, based on the availability of natural resources providing rents to the host countries. Our findings also support these results. Table 5 shows the Spearman's rank correlation test (SRCT) for the two periods: 1991-2019 and 1996-2019. Spearman's rank correlation is a nonparametric measure of rank correlation (statistical dependence between the rankings of two variables) and measures the strength and direction of association between two ranked variables. While Pearson's correlation assesses linear relationships, Spearman's correlation assesses monotonic relationships (whether linear or not). A monotonic relationship is a relationship that does one of the following:

1) as the value of one variable increases, so does the value of the other variable;

2) as the value of one variable increases, the other variable value decreases.

We note that in 1996-2019, the oil and gas rich Azerbaijan had a weak negative (-0.04) SRC of TFP and FDI, while other 9 post-soviet countries had SRC between 0.53 and 0.86. Also, we note that the test scores for Uzbekistan were 0.26 and 0.71 in the two periods, respectively, whereas they were -0.35 and -0.12 for Egypt, respectively. It implies that Uzbekistan's TFP had a strong positive relation with FDI after 1996, whereas Egypt's TFP had a weak negative relation with FDI because of the availability of natural resources. Figure 3 indicates the high TFP figures for oil and gas rich Arab countries such as Saudi Arabia, Kuwait and Oman, whose FDI figures were also negatively correlated with TFP figures (see Table 5). Although we did not carry out the regression analysis on the effect of FDI on TFP for the countries of our interest, yet the correlation analysis we did perform provides significant evidence on the relations.

On 28 January 2022, Uzbek President Shavkat Mirziyoyev signed the New Uzbekistan's Development Strategy for 2022-2026 Decree (LexUz). The document consists of seven priority areas, in particular, the third area "Providing rapid development of the national economy and high growth rate" sets up sixteen goals. The goals associated with investment include:

- to further improve the investment environment in the country and increase its attractiveness, to take measures to attract 120 billion US dollars, including 70 billion dollars of foreign investments in the next five years;

- on the basis of public-private partnership, to attract investments in the amount of $14 billion in the energy, transport, healthcare, education, environment, utilities, water management and other industries;
- to establish foreign economic relations between the business of the provinces of the republic and foreign countries. In particular, to develop investment and foreign economic relations of the Syrdarya province with China, the Surkhandarya province with Russia, the Jizzakh province with India;
- an Investor Assistance Center will be set up in Surkhandarya province, a Business Assistance Center at NMMC in Navoi province, a Center for Advanced Projects and Engineering in Tashkent, and Innovation and Technology Centers in each district to provide practical assistance to businesses;
- the Tashkent International Investment Forum will be held annually in the capital;
- over five years, the stock market turnover is planned to increase from $200 million to $7 billion, complete the transformation process in banks with state shares, and bring the private sector's share in the banking system to 60% by the end of 2026.

A new World Bank report (Jedlicka H. et. al., 2022) provides policy recommendations for Uzbekistan on how to increase foreign direct investment and create new sources of economic growth. The report presents the historical statistics and tendencies on source countries of FDI to Uzbekistan (see Figure 1) and comments "Driven by the BRI (Belt and Road Initiative), Chinese investors proliferated in Uzbekistan. FDI stock from China exceeded 1 billion US dollars in 2019, representing 44 percent of Uzbekistan's total inward FDI stock". The rapid decline of Russian outward FDI to Uzbekistan is due to sanctions imposed on Russia for its war in Ukraine. We note that the FDI from Turkey, Kazakhstan, Germany and Republic of Korea decreased from 2014 to 2019, while new significant investors such as UK, Italy and Netherlands emerged on the scene. The concluding recommendation given in the report is very practical: "Uzbekistan has seen more and more investment from China in recent years, but the Russia-Ukraine conflict has demonstrated the importance of having diversified sources of FDI to avoid overreliance on any single market. More investments from high income source markets are required to improve the quantity and quality of FDI attracted to meet Uzbekistan's economic development objectives". Indeed, diversifying source countries of FDI is the key for stable economic development of Uzbekistan. Historically, Uzbekistan has had strong ties with India and Arab countries in many respects. Attracting more FDI from these countries will not only benefit Uzbekistan but will also promote the Belt and Road Initiative of China and restore the ancient trade routes of Great Silk Road.

Conclusion

In the article we used 3 TFP calculation methods (Pooled OLS, Random Effect and Fixed Effect) for 3 samples of countries (58 countries located on the ancient Great Silk Road, 19 developed and 39 developing countries) and found that the econometric model was significant for the total sample of 58 countries only. For other two samples, the models had the multicollinearity issue, therefore we did not consider them. Using our model, we estimated the TFP figures and described their dynamics for the selected countries, in particular, for the post-soviet states. Among many determinants of the total factor productivity, we used the foreign

direct investment to understand the dynamics of the total factor productivity. With the help of Spearman's rank correlation test we could display the strong relation between TFP and FDI. However, there is a room for further research in terms of carrying out a full econometric analysis of the relationship of TFP and FDI for the countries located on the ancient Great Silk Road.

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Appendix

Table 1. List of countries in samples

	Developed countries
1	Brunei Darussalam (BD)
2	Croatia
3	France
4	Germany
5	Greece
6	Israel
7	Italy
8	Japan
9	Kuwait
10	Oman
11	Portugal
12	Qatar
13	Republic of Korea (RK)
14	Romania
15	Saudi Arabia (SA)
16	Singapore
17	Spain
18	United Arab Emirates (UAE)
19	United Kingdom (UK)

Developing countries	
Albania	Montenegro
Armenia	Mozambique
Azerbaijan	Myanmar
Bangladesh	Nepal
Bulgaria	Pakistan
China	Philippines
Egypt	Russian Federation (RF)
Georgia	Sri Lanka
India	Sudan
Indonesia	Syrian Arab Republic (SAR)
Iran (Islamic Republic of)	Tajikistan
Iraq	Thailand
Jordan	Turkey
Kazakhstan	Turkmenistan
Kenya	Ukraine
Kyrgyzstan	U.R. of Tanzania: Mainland (URT)
Lebanon	Uzbekistan
Madagascar	Viet Nam
Malaysia	Yemen
Mongolia	

Table 2. Descripive statistics

Variables	Samples	Obs.	Mean	Std. dev.	Minimum	Maximum
GDP (rgdpna)	Total (58)	1682	860,465.4	1,866,234	4,317.807	2.06e+07
	Developed (19)	551	1,141,809.0	1,321,795	20,064.190	5,099,254
	Developing (39)	1131	723,400.4	2,067,199	4,317.807	2.06e+07
Capital (rnna)	Total (58)	1682	4,057,808.0	8,110,163	18,104.740	1.02e+08
	Developed (19)	551	6,280,056.0	7,388,315	79,748.190	2.61e+07
	Developing (39)	1131	2,975,175.0	8,227,824	18,104.74	1.02e+08
Labor (emp)	Total (58)	1682	35.67897	111.8013	0.1067	799.3066
	Developed (19)	551	14.07026	17.01161	0.1067	69.97669
	Developing (39)	1131	46.20629	134.5919	0.175885	799.3066

Table 3. Pearson's correlation test

Variables	Total			Developed			Developing		
	GDP	Capital	Labor	GDP	Capital	Labor	GDP	Capital	Labor
GDP (rgdpna)	1			1			1		
Capital (rnna)	0.9487	1		0.9826	1		0.9546	1	
Labor (emp)	0.8000	0.6320	1	0.9680	0.9450	1	0.8702	0.7491	1

Table 4. Sample of 58 countries

	Pooled OLS	Random Effect	Fixed Effect
$\ln rnna\ (\alpha)$	0.7023^{***}	0.7027^{***}	0.7007^{***}
$\ln emp\ (\beta)$	0.2687^{***}	0.2850^{***}	0.2937^{***}
R^2	0.93	0.93	0.93
p-value (F-test)	0.000	0.000	0.000
n	1682	1682	1682

$*$: significant at 10%, $**$: significant at 5%, $***$: significant at 1%.
Note: Hausman test does not reject the null hypothesis (H0: coefficients are consistent under both random and fixed effects or random effect is better) with p-value 0.84 that is not less than 0.01, therefore the Random Effect model is preferred.

Table 5. Means and Standard deviations (SD) of TFP and Spearman's rank correlation test (SRCT) of TFP and FDI for 58 countries for the periods of 1991-2019 (A) and 1996-2019 (B)

	Country	Mean	SD	SRCT	
				A	B
1	Egypt	19.58	1.07	-0.35	-0.12
2	Qatar	17.32	3.13	0.01	0.04
3	Kuwait	17.06	3.71	-0.43	-0.56
4	SA	16.16	2.26	-0.63	-0.55
5	SAR	14.74	3.67	0.91	0.98
6	Iraq	12.96	3.77	0.13	0.19
7	Azerbaijan	12.93	4.66	0.10	-0.04
8	Oman	12.60	2.53	-0.71	-0.69
9	Myanmar	12.24	2.41	-0.62	-0.65
10	Bulgaria	12.15	1.45	-0.50	-0.18
11	Jordan	11.48	0.89	0.69	0.71
12	Pakistan	11.22	1.27	0.79	0.72
13	BD	11.19	1.53	-0.20	0.15
14	Uzbekistan	10.97	1.23	0.26	0.71
15	Israel	10.92	0.73	0.90	0.85
16	Singapore	10.73	0.95	0.84	0.81
17	Sri Lanka	10.69	0.48	0.87	0.85
18	Sudan	10.58	1.21	0.68	0.48
19	Kazakhstan	10.40	3.48	0.73	0.66
20	Turkey	10.33	0.39	0.38	0.55
21	Montenegro	10.03	1.52	0.43	0.69
22	Germany	9.96	0.30	0.42	0.28
23	Romania	9.50	1.41	0.89	0.85
24	UK	9.41	0.56	0.63	0.40
25	Viet Nam	9.31	0.86	-0.75	-0.65
26	China	8.90	0.65	-0.72	-0.58
27	RK	8.87	0.53	0.60	0.44
28	Japan	8.83	0.28	0.13	0.09
29	France	8.77	0.31	0.41	0.28
30	Armenia	8.71	2.99	0.70	0.53
31	UAE	8.66	0.82	0.13	-0.09
32	Kyrgyzstan	8.62	1.47	0.57	0.53
33	Spain	8.61	0.26	0.28	0.23
34	Lebanon	8.12	0.73	0.79	0.73
35	Malaysia	8.11	0.78	0.76	0.76
36	Philippines	8.04	0.95	0.72	0.71
37	Italy	7.98	0.40	-0.30	-0.31
38	Kenya	7.69	0.42	0.67	0.72
39	Croatia	7.52	0.74	0.62	0.42
40	RF	6.91	1.73	0.76	0.71
41	Madagascar	6.77	0.45	-0.19	-0.36
42	Iran	6.73	0.35	0.64	0.56
43	Bangladesh	6.71	0.09	-0.42	-0.58
44	Turkmenistan	6.63	1.69	0.83	0.86
45	URT	6.58	0.60	0.73	0.58
46	India	6.31	0.80	0.92	0.87
47	Greece	6.30	0.55	-0.07	-0.19
48	Nepal	6.12	0.22	-0.10	0.25
49	Thailand	6.00	1.00	0.50	0.38
50	Indonesia	5.97	0.39	0.37	0.69
51	Portugal	5.79	0.18	-0.23	-0.29
52	Mozambique	5.71	1.18	0.69	0.45
53	Yemen	5.56	1.59	0.45	0.57
54	Albania	5.17	1.13	0.92	0.90
55	Georgia	5.05	1.94	0.84	0.86
56	Mongolia	4.40	1.38	0.75	0.62
57	Ukraine	3.24	0.71	0.63	0.67
58	Tajikistan	1.78	0.93	0.78	0.78

Table 6. Transition scores for six qualities of a sustainable market economy

	Competitive (market structures for competition and business standards; Capacity to add value and innovate)	**Well-governed** (National-level governance; Corporate-level governance)	**Green** (Mitigation of climate change; Adaptation to climate change; Other environ-mental areas)	**Inclusive** (Gender equality; Regional disparities; Opportunities for young people)	**Resilient** (Financial stability; Resilient energy sector)	**Integrated** (Openness to foreign trade, investment and finance; Domestic and cross-border infrastruc-ture)
Mean	**4.33**	**4.56**	**5.09**	**5.19**	**5.38**	**5.59**
Albania	4.41	4.31	4.85	5.11	4.86	5.76
Armenia	4.47	4.79	5.41	5.72	5.04	5.94
Azerbaijan	3.64	4.61	5.23	4.71	4.46	5.84
Bulgaria	5.96	4.69	5.82	5.33	6.54	6.86
Croatia	5.75	5.14	6.03	6.03	6.61	6.85
Egypt	2.87	3.90	4.41	4.24	5.41	4.27
Georgia	4.54	5.98	4.58	5.14	5.71	6.54
Greece	6.31	4.34	6.27	5.63	6.67	6.38
Jordan	3.92	5.26	5.65	4.88	5.66	6.12
Kazakhstan	4.30	5.05	4.42	5.37	5.66	5.00
Kyrgyzstan	3.45	3.33	4.36	4.46	4.98	4.94
Mongolia	4.25	4.50	5.28	5.64	4.57	5.68
Montenegro	4.89	5.12	5.15	5.62	5.93	5.59
Romania	6.28	4.97	5.86	5.08	6.98	6.88
Russia	5.20	4.55	4.92	5.94	5.95	5.17
Tajikistan	2.66	3.69	5.58	4.58	3.76	4.23
Turkey	4.89	5.30	5.12	4.21	7.08	5.90
Turkmenistan	1.46	3.83	4.13	4.86	3.12	4.64
Ukraine	4.68	3.58	5.54	5.88	4.60	5.04
Uzbekistan	2.72	4.32	3.20	5.34	3.98	4.20

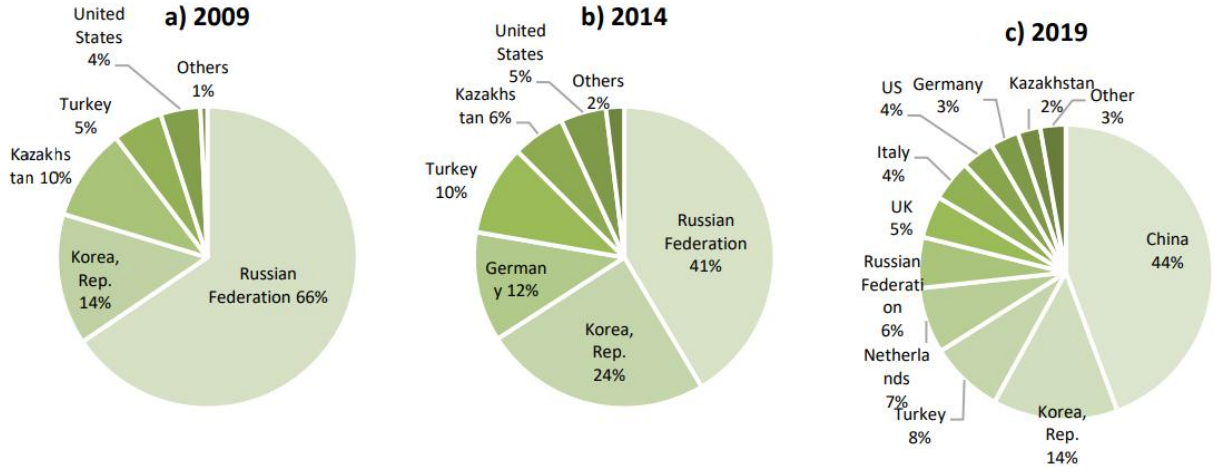
Note: Scores range from 1 to 10, where 10 denotes the synthetic frontier for each quality. The inclusion score for Uzbekistan covers gender equality and regional disparities only. The inclusion score for Turkmenistan covers gender equality only. The scores below means are highlighted.

Table 7. Correlation matrix for TFP figures of 10 post-soviet countries in 1991-2001 / 1991-2019

	ARM	AZB	GEO	KAZ	KYR	RUS	TAJ	TUR	UKR	UZB
ARM	1									
AZB	0.46/0.75	1								
GEO	**0.80/0.91**	**0.86/0.77**	1							
KAZ	0.50/**0.94**	**0.89/0.81**	**0.72/0.97**	1						
KYR	0.60/**0.86**	**0.95/0.83**	**0.89/0.94**	**0.92/0.92**	1					
RUS	0.54/**0.94**	**0.96/0.87**	**0.82/0.96**	**0.96/0.99**	**0.94/0.94**	1				
TAJ	0.35/**0.83**	**0.98**/0.61	**0.78/0.95**	**0.85/0.91**	**0.89/0.87**	**0.93/0.89**	1			

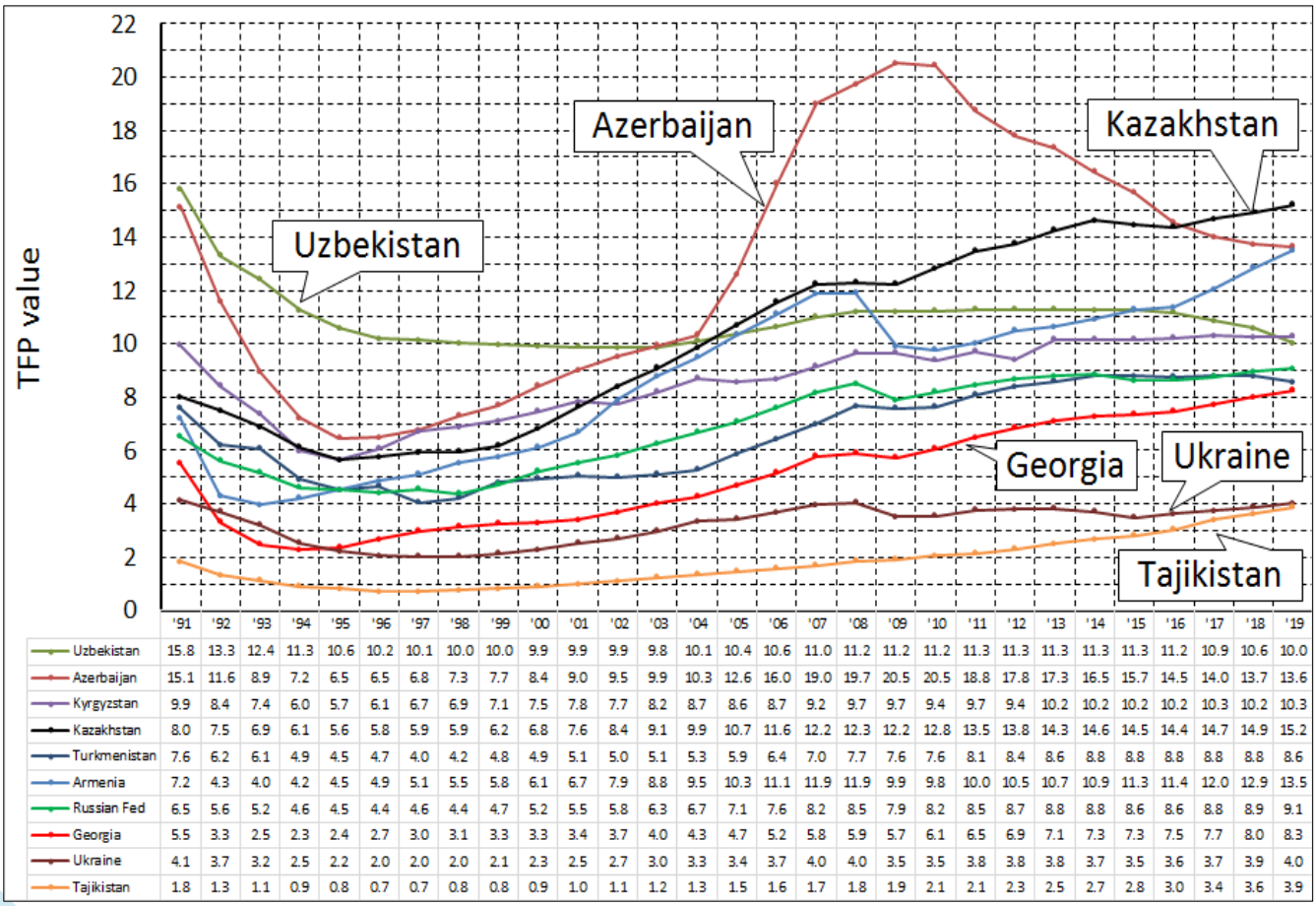
TUR	0.25/**0.79**	**0.94/0.81**	0.69/**0.94**	**0.82/0.93**	**0.84/0.92**	**0.90/0.94**	**0.97/0.92**	1		
UKR	0.12/**0.76**	**0.93/0.84**	0.62/**0.80**	**0.82/0.81**	**0.81/0.89**	**0.87/0.87**	**0.97/0.75**	**0.97/0.86**	1	
UZB	0.11/-0.10	**0.89/0.33**	0.65/0.13	0.66/0.04	**0.74**/0.30	**0.79**/0.12	**0.95**/0.13	**0.94**/0.36	**0.95**/0.50	1

Figure 1. Source countries of FDI to Uzbekistan



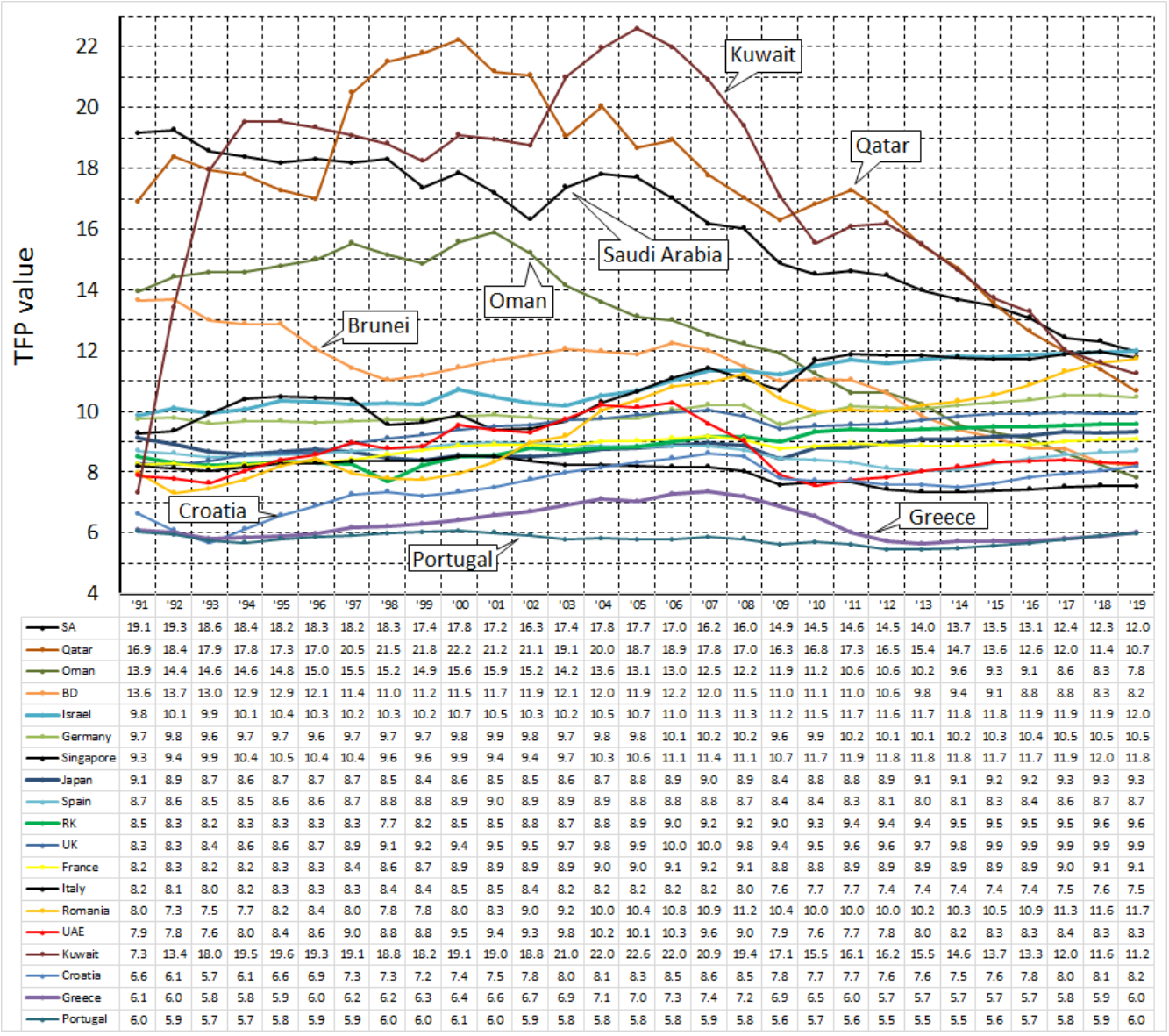
Source: World Bank report

Figure 2. TFP figures for a sample of 10 post-soviet countries.



	'91	'92	'93	'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13	'14	'15	'16	'17	'18	'19
Uzbekistan	15.8	13.3	12.4	11.3	10.6	10.2	10.1	10.0	10.0	9.9	9.9	9.9	9.8	10.1	10.4	10.6	11.0	11.2	11.2	11.2	11.3	11.3	11.3	11.3	11.3	11.2	10.9	10.6	10.0
Azerbaijan	15.1	11.6	8.9	7.2	6.5	6.5	6.8	7.3	7.7	8.4	9.0	9.5	9.9	10.3	12.6	16.0	19.0	19.7	20.5	20.5	18.8	17.8	17.3	16.5	15.7	14.5	14.0	13.7	13.6
Kyrgyzstan	9.9	8.4	7.4	6.0	5.7	6.1	6.7	6.9	7.1	7.5	7.8	7.7	8.2	8.7	8.6	8.7	9.2	9.7	9.7	9.4	9.7	9.4	10.2	10.2	10.2	10.2	10.3	10.2	10.3
Kazakhstan	8.0	7.5	6.9	6.1	5.6	5.8	5.9	5.9	6.2	6.8	7.6	8.4	9.1	9.9	10.7	11.6	12.2	12.3	12.2	12.8	13.5	13.8	14.3	14.6	14.5	14.4	14.7	14.9	15.2
Turkmenistan	7.6	6.2	6.1	4.9	4.5	4.7	4.0	4.2	4.8	4.9	5.1	5.0	5.1	5.3	5.9	6.4	7.0	7.7	7.6	7.6	8.1	8.4	8.6	8.8	8.8	8.8	8.8	8.8	8.6
Armenia	7.2	4.3	4.0	4.2	4.5	4.9	5.1	5.5	5.8	6.1	6.7	7.9	8.8	9.5	10.3	11.1	11.9	11.9	9.9	9.8	10.0	10.5	10.7	10.9	11.3	11.4	12.0	12.9	13.5
Russian Fed	6.5	5.6	5.2	4.6	4.5	4.4	4.6	4.4	4.7	5.2	5.5	5.8	6.3	6.7	7.1	7.6	8.2	8.5	7.9	8.2	8.5	8.7	8.8	8.8	8.6	8.6	8.8	8.9	9.1
Georgia	5.5	3.3	2.5	2.3	2.4	2.7	3.0	3.1	3.3	3.3	3.4	3.7	4.0	4.3	4.7	5.2	5.8	5.9	5.7	6.1	6.5	6.9	7.1	7.3	7.3	7.5	7.7	8.0	8.3
Ukraine	4.1	3.7	3.2	2.5	2.2	2.0	2.0	2.0	2.1	2.3	2.5	2.7	3.0	3.3	3.4	3.7	4.0	4.0	3.5	3.5	3.8	3.8	3.8	3.7	3.5	3.6	3.7	3.9	4.0
Tajikistan	1.8	1.3	1.1	0.9	0.8	0.7	0.7	0.8	0.8	0.9	1.0	1.1	1.2	1.3	1.5	1.6	1.7	1.8	1.9	2.1	2.1	2.3	2.5	2.7	2.8	3.0	3.4	3.6	3.9

Figure 3. A sample of 19 developed countries.



	'91	'92	'93	'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13	'14	'15	'16	'17	'18	'19
SA	19.1	19.3	18.6	18.4	18.2	18.3	18.2	18.3	17.4	17.8	17.2	16.3	17.4	17.8	17.7	17.0	16.2	16.0	14.9	14.5	14.6	14.5	14.0	13.7	13.5	13.1	12.4	12.3	12.0
Qatar	16.9	18.4	17.9	17.8	17.3	17.0	20.5	21.5	21.8	22.2	21.2	21.1	19.1	20.0	18.7	18.9	17.8	17.0	16.3	16.8	17.3	16.5	15.4	14.7	13.6	12.6	12.0	11.4	10.7
Oman	13.9	14.4	14.6	14.6	14.8	15.0	15.5	15.2	14.9	15.6	15.9	15.2	14.2	13.6	13.1	13.0	12.5	12.2	11.9	11.2	10.6	10.6	10.2	9.6	9.3	9.1	8.6	8.3	7.8
BD	13.6	13.7	13.0	12.9	12.9	12.1	11.4	11.0	11.2	11.5	11.7	11.9	12.1	12.0	11.9	12.2	12.0	11.5	11.0	11.1	11.0	10.6	9.8	9.4	9.1	8.8	8.8	8.3	8.2
Israel	9.8	10.1	9.9	10.1	10.4	10.3	10.2	10.3	10.2	10.7	10.5	10.3	10.2	10.5	10.7	11.0	11.3	11.3	11.2	11.5	11.7	11.6	11.7	11.8	11.8	11.9	11.9	11.9	12.0
Germany	9.7	9.8	9.6	9.7	9.7	9.6	9.7	9.7	9.7	9.8	9.9	9.8	9.7	9.8	9.8	10.1	10.2	10.2	9.6	9.9	10.2	10.1	10.1	10.2	10.3	10.4	10.5	10.5	10.5
Singapore	9.3	9.4	9.9	10.4	10.5	10.4	10.4	9.6	9.6	9.9	9.4	9.4	9.7	10.3	10.6	11.1	11.4	11.1	10.7	11.7	11.9	11.8	11.8	11.8	11.7	11.7	11.9	12.0	11.8
Japan	9.1	8.9	8.7	8.6	8.7	8.7	8.7	8.5	8.4	8.6	8.5	8.5	8.6	8.7	8.8	8.9	9.0	8.9	8.4	8.8	8.8	8.9	9.1	9.1	9.2	9.2	9.3	9.3	9.3
Spain	8.7	8.6	8.5	8.5	8.6	8.6	8.7	8.8	8.8	8.9	9.0	8.9	8.9	8.9	8.8	8.8	8.8	8.7	8.4	8.4	8.3	8.1	8.0	8.1	8.3	8.4	8.6	8.7	8.7
RK	8.5	8.3	8.2	8.3	8.3	8.3	8.3	7.7	8.2	8.5	8.5	8.8	8.7	8.8	8.9	9.0	9.2	9.2	9.0	9.3	9.4	9.4	9.4	9.5	9.5	9.5	9.5	9.6	9.6
UK	8.3	8.3	8.4	8.6	8.6	8.7	8.9	9.1	9.2	9.4	9.5	9.5	9.7	9.8	9.9	10.0	10.0	9.8	9.4	9.5	9.6	9.6	9.7	9.8	9.9	9.9	9.9	9.9	9.9
France	8.2	8.3	8.2	8.2	8.3	8.3	8.4	8.6	8.7	8.9	8.9	8.9	8.9	9.0	9.0	9.1	9.2	9.1	8.8	8.8	8.9	8.9	8.9	8.9	8.9	8.9	9.0	9.1	9.1
Italy	8.2	8.1	8.0	8.2	8.3	8.3	8.3	8.4	8.4	8.5	8.5	8.4	8.2	8.2	8.2	8.2	8.2	8.0	7.6	7.7	7.7	7.4	7.4	7.4	7.4	7.4	7.5	7.6	7.5
Romania	8.0	7.3	7.5	7.7	8.2	8.4	8.0	7.8	7.8	8.0	8.3	9.0	9.2	10.0	10.4	10.8	10.9	11.2	10.4	10.0	10.0	10.0	10.2	10.3	10.5	10.9	11.3	11.6	11.7
UAE	7.9	7.8	7.6	8.0	8.4	8.6	9.0	8.8	8.8	9.5	9.4	9.3	9.8	10.2	10.1	10.3	9.6	9.0	7.9	7.6	7.7	7.8	8.0	8.2	8.3	8.3	8.4	8.3	8.3
Kuwait	7.3	13.4	18.0	19.5	19.6	19.3	19.1	18.8	18.2	19.1	19.0	18.8	21.0	22.0	22.6	22.0	20.9	19.4	17.1	15.5	16.1	16.2	15.5	14.6	13.7	13.3	12.0	11.6	11.2
Croatia	6.6	6.1	5.7	6.1	6.6	6.9	7.3	7.3	7.2	7.4	7.5	7.8	8.0	8.1	8.3	8.5	8.6	8.5	7.8	7.7	7.7	7.6	7.6	7.5	7.6	7.8	8.0	8.1	8.2
Greece	6.1	6.0	5.8	5.8	5.9	6.0	6.2	6.2	6.3	6.4	6.6	6.7	6.9	7.1	7.0	7.3	7.4	7.2	6.9	6.5	6.0	5.7	5.7	5.7	5.7	5.7	5.8	5.9	6.0
Portugal	6.0	5.9	5.7	5.7	5.8	5.9	5.9	6.0	6.0	6.1	6.0	5.9	5.8	5.8	5.8	5.8	5.9	5.8	5.6	5.7	5.6	5.5	5.5	5.5	5.6	5.7	5.8	5.9	6.0