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RESEARCH ARTICLE

Analyzing the role of information and telecommunication technology in human development: panel data analysis

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Abstract

Economic growth in modern-day world get attention primarily through innovation and higher productivity, which places technology and knowledge at the core of the issue on economic policy. In this regard, information and communication technology (ICT) has a unique place for offering the potential to improve efficiency, promote the sharing of knowledge, and improve innovation leading to an overall change in social and human development processes around the globe. This study examines the role of ICT and economic growth on human development. A family of econometric series robust to cross-sectional dependence is applied for a panel of five selected South Asian countries over 1990–2016. The ICT in the study were measured through mobile phone and internet penetration. The results of Driscoll-Kraay standard errors algorithm suggest that mobile phone usage promotes human development, whereas internet usage does not seem to do so. Apart from it, its economic growth does contribute to the promotion of human development. Policy implications are required in the direction for internet usage to produce its role in human development.

Keywords Human development index · Information and communication technology (ICT) · South Asian economies · Driscoll-Kraay standard errors method

Introduction

In the last few decades, the world has indeed become a global village with more significant and faster modes of connectivity. Information and communication technologies (ICTs) are considered as a double-edged sword for achieving sustainable development in terms of both attempting long-term sustainable economic growth and resolving environmental issues (Hou et al. 2015). The advancement of ICTs has impacted every sphere of life; ranging from education to culture, business to services, entertainment to art, and infrastructure to transportation (Lee et al. 2017). The use of ICTs increases day by day. As per the international telecommunication union (ITU) report, the number of internet users has taken a massive jump from 400 million in 2000 to 3.2 billion in 2015 (ITU 2015).

Until the mid-twentieth century, income was considered an essential component of economic growth, but gradually, the emphasis shifted from income to human development and technological advancement (District et al. 2014; Asongu 2018). The knowledge and skills of human in the form of human development coupled with physical material are treated as complementary input in the process of production and development of any country (Teixeira and Queirós 2016; Mustafa et al. 2017). Human development consists of a broad spectrum of choices. The range of choices includes living a long and healthy life, a better standard of living, and per capita income (District et al. 2014; Yakunina and Bychkov 2015). Recently, ICTs are being diffused into almost all spheres of human activities (Latif et al. 2017a). Besides this, ICTs contribute to increase growth and productivity on the one hand, and human development and welfare on the other hand in both developing and developed countries (Biggeri and Mauro 2018).

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The ICTs do not only influence economic growth but human development as well both in developed and developing countries. Particularly, the South Asian region is blessed with abundance of natural resources but lower GDP growth rates in recent years. The part comprises seven core countries, namely Afghanistan, Bangladesh, Bhutan, India, Nepal, Pakistan, and Sri Lanka. The countries in the selected region almost have similar culture and economic, social, and geopolitical conditions, and they are sharing common boundaries via land and water. South Asian countries covered 3.5% of the world's land surface area and accommodated 1/4th (24.89%) of the world population. Population in South Asia is expected to increase by 0.4–1.9% (Mohsin et al. 2018). The region has a cumulative $2.6 trillion gross domestic product (GDP) (Abbas et al. 2018). Apart from this, access to primary education, decent living of standard, high life expectancy, and basic health facilities are considered important human development indicators. With life expectancy, Sri Lanka is the country with a high life expectancy of 70 years. While in all other South Asian countries, life expectancy falls in the range of 62–63 years.

Furthermore, if we look into the public spending priorities in the region, most of the countries in the region are spending only 3–5% of the total GDP on education and health advancement collectively (Lee et al. 2017). According to a recent report of global competitiveness index, Nepal is on top in the region with 40.4 scores in ICT adaptation, while Bangladesh scored 39.9, Sri Lanka scored 32.9, and India scored 28 followed by Pakistan with 23.6 in ICT adaptation (Pradhan et al. 2018). The recent literature related to ICTs has shown that there is enough room for an investor to invest in ICT spheres as the current scenario and the regions are considered favorite investment destination for multinational ICT companies (Latif et al. 2017b). Based on the above social, technological, and human developments, indicators reveal that the human development (health, education, and decent life of standard) and ICTs in the region are below the average. Thus, it is the need of the hour to research and explore the ways and means to contribute to the development of ICTs and human development index in South Asian countries.

Given the above background and knowing the importance of the ICTs for human development process motivate us to analyze the role information and communication technology (ICT) and economic growth on human development in the South Asian countries, which is particularly useful not only for human development but also essential for promoting economic growth in the region. To fill this knowledge gap and contribute to the emerging literature, we employ a Driscoll-Kraay standard errors technique covering panel unit root tests allowing for cross-sectional dependence. This research has the following objectives and contributions to the existing research: Firstly, this study analyzes the role of ICTs in the human development index. A number of researchers extensively investigated the relationship between ICTs and economic growth by using different data set and methodologies, but this particular area still needs to be researched considering human development index variable with ICTs to check the impact of both variables on economic growth in the context of South Asian countries. Secondly, this study incorporates the latest and long pooled dataset to elaborate on the relationship between ICTs and economic growth in human development index. Thirdly, the novelty of the present study is to investigate the relationship between ICTs and human development index incorporating economic growth, FDI, and trade as a control variable to avoid speciation bias. To examine the relationship between ICTs and human development index, the principles of economic development need to be focused since the subject falls under the domain of developmental economics.

The rest of the article is organized as follows. The "Theoretical perceptive and literature review" section reviews the literature. The "Data source, model specification, and econometric strategy" section provides information on our model specification and data sources. The "Results' discussion" section contains our results and further discussion. Finally, "Conclusion" concludes the study.

Theoretical perceptive and literature review

This section provides a theoretical background and review of prior studies. In the first part, we will discuss the theoretical background. The second part will present a review of previous studies related to ICTs and human development index. In the third and final part, we will review the literature regarding ICTs, economic growth, FDI, and trade.

Theories of economic growth

In the prior literature, the theory of human development has taken the place of the classical theory of economic growth. The base on the classical theory of economic growth was laid on the phenomena of gross national product (GNP), the final value of the goods and services produced within the country territory during a specified period, usually a year (Khodabakhshi 2011). The neoclassical growth model (Solow 1965) suggested that long-run economic growth depends on external factors such as technological development and population growth (Hong et al. 2016; Donou-Adonsou 2018). However, unlike the Solow growth model where technological progress is considered as an exogenous, a new growth model comes out an endogenous technological advancement. Lucas (1990) suggests that technological advancement depends on human development, and the combination of both leads to economic growth (Kooshki and Ismail 2011; Sepehrdoust 2018). According to the new economic growth model, Romer (1989) suggested that creativity or

new ideas have an impact on technological advancement which then determines economic growth and human development (Niebel 2018; Pradhan et al. 2015; Mikucka et al. 2017).

Information communication technology and human development

Modern economic growth models and practices put a lot of emphasis on the role of ICTs on human development and their importance for long-term economic growth (Hou et al. 2015; Ogundari and Awokuse 2018). The ICT literature is characterized by a tremendous development in human capabilities, improvement in health status, and increases in life expectancy (Yakunina and Bychkov 2015; Lee et al. 2017; Mikucka et al. 2017; Rivera 2017; Bucci et al. 2018). ICT is considered the heart of human progress and it does not only contribute to economic growth but also improved the education, health, and living of standard of the populace (Bankole and Mimbi 2017). In modern days, ICT plays a dual role both as an input and as an output: as input, ICTs lower coordination costs in markets, and as an output, ICTs improved public services such as health and education through e-services (Hwang and Shin 2017b).

Meanwhile, Asongu and Nwachukwu (2018) use 49 sub-Saharan African countries' data. The study finds a positive marginal effect between ICTs and education quality through e-education. ICTs enlarge people's choices, access to the wealth of knowledge, and the identification of alternatives that would make their life better. The use of e-health in medicine for knowledge management and service delivery, a combination which can improve the delivery of medical services, can, by consequence, improve health outcomes.

Moreover, e-healthcare increases medical knowledge, improves outcomes, reduces cost, and extends services (Heeks 2015; Asongu and Nwachukwu 2017). Similarly, ICTs increase human capabilities that directly contribute to human development and economic growth (Latif et al. 2017a; Lee et al. 2017). Using the 49 countries' data by Asongu et al. (2017) explained that there is a direct and robust correlation between inclusive human development and economic growth. The relationship between inclusive human development and economic growth is positive in developed countries, while the correlation between inclusive human development and economic growth is negative in developing countries. The work of Lee et al. (2017) stated that ICTs and human development both contribute positively to economic growth. While Qiu et al. (2018) identified that ICTs and human development play a key role in the production process and economic growth.

ICTs, economic growth, FDI, and trade

The importance of ICTs in economic growth has been widely discussed in previous studies. For example, more recently, Asongu and Le Roux (2017) studied the impact of ICT on sustainable development by using panel data for 49 countries of sub-Saharan Africa which demonstrated that ICT positively contributes to economic growth and development. Few recent quantitative studies examined the impact of ICTs on economic growth (Vu 2013; Jin and Moon 2015; Jorgenson and Vu 2016; Latif et al. 2017a) and explored the ways and means to benefit ICT expansion economically; for instance, around the world, a rapid increase in ICTs has been witnessed shifting to e-governance from conventional mode of governance. Likewise, access to digital media like cell phones, internet, and social media has a recently significant influence not only on the social aspects of everyday life but also is a useful tool for sustainable development (Kooshki and Ismail 2011; Albiman and Sulong 2017; Chung 2018; Sepehrdoust 2018). According to Vu (2013), technology is capable of many forms of expression, as knowledge and information, as skills and capabilities, as trade, as economic growth, and as human-built structures (Edquist and Henrekson 2017).

Other empirical studies suggest that ICTs significantly contribute to GDP per capita income, reduce the cost of transportation, and increase the ratio of national and international trades (Hong et al. 2016; Pradhan et al. 2018). The impact of ICTs on economic growth is well established in prior studies. Especially, these studies by Mehta and Kalra (2006), Hwang and Shin (2017a), and Asongu and Nwachukwu (2018) stated that ICT is contributing to the production process in many ways; it can be direct, and the more we move towards digitalization or technology, the more saving of resources and time. And it can also have an indirect impact through the usage of tools and goods of ICTs in other sectors as a production process tool. By using that tool in the production process, productivity ultimately improves. It is also found by Hwang and Shin (2017b) and Vu (2017) that ICT sector itself generates revenue and employment opportunities.

Furthermore, it enhances market information, minimizes logistic and transaction cost, and improves the facilities that lead to strengthening economic growth. The long-term economic growth has found to have been increased with the betterment of knowledge preservation and sharing; with enhancing mode of ICTs, we can preserve more knowledge by using less paper or maybe paperless knowledge (Jung et al. 2013; Qureshi and Najjar 2017). Knowledge and ideas can travel fast via the internet, and it can be shared via clouds or hard drives. Also, internet saves time and fastens the overall process which in turn leads to positive impacts on economic growth (Vu 2011; Frey 2016; Lee et al. 2017; Biggeri and Mauro 2018). Hence, there is a mutually positive relationship between ICTs, income, and human development, and these

positively contribute to economic integration, technological advancement, and institution improvement (Kuyoro et al. 2012). To sum up the literature, it is evident that ICTs, human development, economic growth, trade, and FDI are interrelated. The prior literature suggests that ICTs positively contribute to human development, economic growth, FDI, and trade.

Data source, model specification, and econometric strategy

Data source

The annual panel data was collected from 1990 to 2016 for five South Asian countries from World Development Indicators (WDI) and the United Nations Development Programme (UNDP). The adopted periodicity and scope of inquiry are based respectively on data availability and the motivation discussed in the "Introduction." It is important to note that the human development index represents the average achievement of nations in three fundamental dimensions, namely (i) health and long life, (ii) knowledge, and (iii) basic living standard. Thus, the human development index is the sum of three indicators: the EI (education index), the LEI (life expectancy index), and the GDP index (GDPI) (Khan et al. 2018; Wang et al. 2018). ICTs are measured as the number of internet and mobile users per 100 populations which is consistent with the literature (Danish et al. 2018a). The countries' economic growth is measured as real GDP per capita (in constant 2010 USD). FDI is estimated as FDI inflow as a percent of GDP. Trade ratio is the sum of imports and exports as a percent of GDP. To avoid variable omission bias, three control variables are employed, namely economic growth (GDP), foreign direct investment (FDI), and trade. The data used in this study are transformed into natural logarithms to ease interpretation of the coefficient estimates as the elasticities of the analyzed variables. The descriptive statistic and correlation matrix are given in Table 1.

Model specification

This study aims to analyze the role of ICTs and economic growth in human development incorporating the trade openness, and foreign direct investment. The logarithmic form of the relationship among variables of consideration is expressed as follows:

$$\begin{aligned}\mathrm{LogHDI}_{it} = {} & \alpha_0 + \alpha_1(\mathrm{LogICT}_{it}) + \alpha_2(\mathrm{LogGDP}_{it}) \\ & + \alpha_3(\mathrm{LogFDI}_{it}) + \alpha_4(\mathrm{LogTR}_{it}) + \omega_0\end{aligned} \quad (1)$$

where logic is information and telecommunication measured through the internet and mobile usage penetration; HDI is the human development index; GDP is the gross domestic product per capita; FDI is a foreign direct investment, and TR is traded ration. Moreover, ω, i, and t are error term, some countries, and time, respectively. If more budgets are allocated to the ICT sector, it will bring more advancement in the education and health sectors through e-services and e-governance. Rising economic growth, FDI, and trade have a significant impact on human development (Latif et al. 2017a). Also, Hafner and Mayer-Foulkes (2013) found a significant relationship between income and human development. Moreover, the work of Ioannides et al. (2008) points out that the increase in ICTs increases international trade and foreign direct investment.

Econometric strategy

This study will analyze the role of ICTs and economic growth in human development in the South Asian countries. For this purpose, econometric policies are adopted to control for specific characteristics, notably regression with Driscoll-Kraay standard error technique. We employ the Driscoll-Kraay error technique (Driscoll and Kraay 1998) for analyzing the role of ICTs and economic growth in human development for South Asian countries. For employing Driscoll-Kraay standard error technique, we follow two steps: (i) take averages of the product between independent variables and residuals, and (ii) then use these values in the weighted HAC estimator to produce standard errors that now have the added feature of being robust against cross-sectional dependence (Özokcu and Özdemir 2017; Baloch et al. 2019). The advantages of Driscoll-Kraay conventional error technique are the following: (i) to resolve the issue of heteroscedasticity and cross-sectional dependence in the panel data, (ii) to remove the deficiencies of large constant covariance matrix estimations, and (iii) Driscoll-Kraay standard error technique handles missing values and is applicable in both balanced and unbalanced panel data. Furthermore, Driscoll-Kraay conventional error technique was employed when the presence of heteroscedasticity and spatial and serial dependence in the panel data is detected (Heberle and Sattarhoff 2017; Pei et al. 2017). That is why we are using Driscoll-Kraay standard error technique.

Results' discussion

Economic variables are often non-stationary that leads to produce spurious results. Therefore, it is necessary to check the stationary level to obtain reliable and unbiased results. This study employs second-generation panel root tests particularly CIPS and CADF tests due to the following reasons. CIPS and

Table 1 Results of descriptive statistic and correlation matrix

	LOGHDI	LOGGDP	LOG internet	LOG mobile	LOGFDI	LOGTR
Descriptive statistic						
Mean	0.5324	2.941613	0.206021	0.329716	−0.313022	1.607161
Median	0.5140	2.911337	0.641474	0.294346	−0.116655	1.621470
Maximum	0.7680	3.575099	1.879198	2.073699	0.564468	1.947612
Minimum	0.3780	2.552919	− 3.953475	− 3.652945	−2.347612	1.195194
Std. dev.	0.103505	0.250654	1.306739	1.420486	0.628316	0.168365
Observations	135	135	135	135	135	135
Correlation matrix						
LOGHDI	1					
LOGGDP	0.9191	1				
LOG internet	0.2133	0.2372	1			
LOG mobile	0.5506	0.4798	0.2795	1		
LOGFDI	0.5347	0.6491	− 0.0128	0.4321	1	
LOGTR	0.6431	0.5135	0.0331	0.2637	0.3709	1

CADF panel root tests counter the problem of homogeneity. Moreover, these tests are robust to cross-sectional dependence and heterogeneity. The results shown in Table 2 indicate that GDP, ICT internet, ICT mobile, human development index, FDI, and trade contain unit root at their levels but become stationary at their first difference.

As from Table 2, it can be perceived that all the variables under consideration are integrated at first-order difference. Therefore, it is essential to know about cointegration among variable before regression analysis[1]. As there may be the possibility of CD and heterogeneity in the data, so keep this in view that the study prefers Westerlund (2007) cointegration, which helps to counter CD issue in the panel data (Danish and Wang 2018). The results of Westerlund cointegration test is reported in Table 3. The results suggest for the presence of cointegration among ICTs, economic growth (LOGGDP), human development index (LOGHDI), trade ratio (LOGTR), and foreign direct investment (LOGFDI).

The empirical results for regression with Driscoll Kraay standard errors and Prais-Winsten regression are presented in Table 4. The left side presents the regression with Driscoll-Kraay standard errors, and on the right side, Prais-Winsten regression is presented. For results' validity, we use Prais-Winsten regression. The empirical finding of Table 3 shows that the coefficient value of economic growth is positive and significant. The finding of economic growth in long-run indicates that a 1% increase in economic growth leads to a 3.6% increase in human development index. Increasing trade openness, integration, and global economies are now inevitable in South Asian countries. Nursing economic growth may lead to an improvement in health, education, and life expectancy. When people have a high income, they can spend more money on their health and education and improve their standard of life. People with high income can spend more money on quality of food, clothes, and shelter that can lead to increase the life expectancy and decrease the mortality rate of the people in the region/countries.

Furthermore, they can spend more money on good quality of education to improve their skills and get a good job in the future. The results, also consist those of Hafner and Mayer-Foulkes (2013), showed that there is a long-run causal relationship between high income and human development. Also, Kuyoro et al. (2012) argue that health gained center stage to economic growth, improvement in nutrition, and health facilities can increase the productivity that leads to economic growth.

From Table 4, it can be seen that the effect of mobile phone usage on the human development index is positive and significant. We noticed after analyses that the impact of internet usage on human development is higher and significant. Technology is a vital component in everyday life; the smartphone is such a technology that improved the people's living standard, provides opportunities to learn new things,

Table 2 Panel unit root test

	Level		First difference		Decision
Variables	CIPS	CADF	CIPS	CADF	
Log GDP	− 3.239	− 2.513	− 4.775*	− 3.851*	I (1)
Log ICT $_{internet}$	− 3.376	− 5.437	− 4.945*	− 5.081*	I (1)
Log ICT $_{mobile}$	− 2.148	− 2.628	− 4.853*	− 3.914*	I (1)
Log HDI	− 1.303	− 1.554	− 4.083*	− 4.452*	I (1)
Log FDI	− 2.665	− 2.563	− 5.289*	− 3.996*	I (1)
Log TR	− 1.698	− 1.685	− 4.611*	− 2.916***	I (1)

* and *** show 1% and 10% level of significance, respectively

[1] Here is worth mentioning that we are thankful to the reviewer for their concern and raising important point.

Table 3 Results of Westerlund ECM panel cointegration tests

	Internet penetration			Mobile phone penetration			
Statistic	Value	*Z* value	*P* value	Statistic	Value	*Z* value	*P* value
Gt	− 1.915	0.756	0.775	Gt	− 2.292	− 0.140	0.444
Ga	− 17.09	− 1.949	0.026*	Ga	− 18.53	− 2.406	0.008**
Pt	− 2.054	1.694	0.955	Pt	− 2.092	2.084	0.981
Pa	− 6.921	0.184	0.573	Pa	− 5.594	0.636	0.738

* and ** show level of significance at 1% and 5%, respectively

and enhances business development (Lee et al. 2017). Like other countries in the world, the role of the mobile phone is also significant in South Asian countries. Through a smartphone, people have easy access to information about health and education and a better standard of living. In South Asia, the people use a smartphone for education to increase their learning capabilities, for health to keep updating about the health issues, and for long life to learn some indoor and easy exercises to keep them healthy and fit (Mireku et al. 2018).

According to the results, there is a significant and negative impact of internet usage on the human development index. From the findings, it is observed that the internet usage causes to decrease the human development index. Using technology creates more employment opportunities, expands trade activities, and increases economic growth. But in the South Asian region, with the lack of awareness and lack of accesses to the internet, people do not know how to take benefits from internet usage. The selected sample of countries has a lack of the resources to equip their people from a knowledge-based economy to receive maximum benefits from modern tools and technology. Our result validates the work of Asongu and Le Roux (2017).

Further, the association between trade and human development index is positive and significant. The results show that a 1% increase in trade may lead to a rise of 1.4% in the human development index. Trade and human development index are interlinked; business can provide a better life, more opportunities, ensure sustainability, and increase productivity that directly or indirectly affects human capital. Mukherjee and Chakraborty (2010) point out that there is a causal relationship between trade openness and a decent standard of living.

In Table 4, the results show exciting association between foreign direct investment and the human development index; there is a significant but negative relationship between foreign

Table 4 The result of regression with Driscoll Kraay standard errors and Prais-Winsten regression

	Dependent variable = human development index							
	Regression with Driscoll Kraay standard errors				Prais-Winsten regression			
	(1)		(2)		(3)		(4)	
	Internet use penetration		Mobile phone penetration		Internet use penetration		Mobile phone penetration	
Variables	Coefficient	(prob)	Coefficient	(prob)	Coefficient	(prob)	Coefficient	(prob)
Constant	− 0.7111*	0.000	− 0.7111*	0.000	− 0.5997*	0.000	− 0.5829*	0.000
LogGDP	0.3627*	0.000	0.3392*	0.000	0.3669*	0.001	0.3627*	0.000
LogFDI	− 0.0204**	0.024	− 0.0257*	0.005	8.1600	0.996	0.0002	0.898
LogTR	0.1464*	0.001	0.1454*	0.002	0.0407*	0.001	0.0409*	0.001
$\text{LogICT}_{\text{mobile}}$	–	–	0.0117*	0.000	–	–	0.0034*	0.002
$\text{Log}_{\text{Internet}}$	− 0.0003	0.937	–	–	− 0.0001	0.812	–	–
R-squared	0.8933		0.9127		0.9800		0.9847	
Root MSE	0.0343		0.0311					
Prob>f	0.0000		0.0000					
Prob>chi^2					0.0000		0.0000	
Groups	5	5	5	5	5	5	5	5
Observation	135	135	135	135	135	135	135	135

* and ** show significant level at the 1% and 5%, respectively

HDI, human development index; *TR*, trade ration; *FDI*, foreign direct investment; *RMSE*, root mean square error

direct investment and human development index. It means foreign direct investment does not affect the human development index. The lack of foreign direct investment is known to be one of the basic reasons for many countries being caught in the vicious cycle of poverty. The lack of political stability and corruption discourages foreign direct investment which adversely influences human development index in the region. The less inflow of foreign direct investment can provide limited employment opportunities that directly affect human living standard. According to Mustafa et al. (2017), the poor governance, corruption, and political instability are the main reasons of low foreign direct investment (FDI) in South Asian countries.

Conclusion

The goal of this study is to analyze the role of ICT and economic growth in human development in the South Asian countries over the time from 1990–2016, the most extended available data. The panel unit root test was used which was helpful in resolving the issue of cross-section dependence. For empirical estimation, Driscoll-Kraay standard error approach is employed that produced robust estimates in the presence of cross-sectional dependence. The study provides some critical findings. The positive and significant relationship between mobile phone usage and human development is found. Further, internet usage has an insignificant effect on human development. Moreover, economic growth plays a significant role in human development in Asian countries.

From the result, several policy directions can be suggested to solve the mighty problems faced by regions like South Asia. The considerable investment and a large number of mobile phone usages promote human development in the region. Through mobile, people easily communicate and transfer knowledge regarding health and education, etc. However, internet usage is not the priority of the people due to high prices in the region; only a few mobile users use internet via mobile phones for an un-productive purpose such social media, video, and sharing, which is not that productive for human development in the region. The following points are suggested for policymakers in the South Asian countries: (i) Countries in the South Asian region need to provide easy access to the internet in their respective countries; (ii) encourage more investment for the promotion of the internet that would play a key role in human development and sustainable economic growth; (iii) need to introduce e-culture in the region to improve education, health, and human development; (iv) need to improve the quality of infrastructure and connectivity; and (v) need to reduce the prices of ICT equipment and make affordable mobile and internet packages for masses to take maximum benefits from technology.

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