Journal of Indian Studies
Vol. 7, No. 1, January – June, 2021, pp. 81– 92

Infrastructure and Economic Growth in South Asian Countries

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ABSTRACT

Infrastructure is one of the important determinants of economic growth which have significant part in the development of an economy. This paper evaluates the relationship between infrastructure and economic growth in South Asian countries for the time period of 19 years from 2001 to 2019. Using fixed effects and random effects model, we report that there is a direct relationship between infrastructure and economic growth in South Asian countries. Our findings suggest that South Asian countries should direct their investments towards infrastructure projects to enhance their growth.

Key Words: **Infrastructure, Economic Growth, Fixed Effects Model & Random Effects Model.**

Introduction

Infrastructure projects increase wealth of nations besides increasing living standard of citizens. They not only serve as an input to various processes but also facilitate other production processes. It implies that infrastructure also raises total factor productivity, for example, by means of reducing transaction costs.

The term infrastructure tends to include various factors. Therefore, it is relatively a difficult task to define infrastructure in exact terms. However, reviewing the work on infrastructure finds definition of Gramlich (1994) making sense. This work reports that, "…definition that makes the most sense from an economics standpoint consists of large capital intensive natural monopolies such as highways, other transport facilities, water and sewer lines, and communications systems."

Infrastructure facilities are further classified into categories according to their specifications. Economic infrastructure serves as a common input to various industries and is defined as "physical assets available for conducting business activities, including communications, transportation and distribution networks."

On the other hand, social infrastructure includes "physical assets that support the social development of a community, including education, health and public housing facilities" (Chan, Forwood, Roper, & Sayers, 2009). Besides economic infrastructure, importance of social infrastructure cannot be denied also. Both have direct association with economic growth (Kiumari & Sharma, 2017).

Economic and social infrastructure constitutes a crucial part of an economy. There is a handful of research available which repots direct relationship between infrastructure and economic growth (Saidi, Shahbaz, & Akhtar, 2018) (Pradhan, Malik , & Bagchi, 2018) (Khan, 2020). These researches vary in used variables, geography and estimations techniques. According to Straub (2008), literature on infrastructure overlooks geographical dimension and it is not an easy task to capture the whole picture of infrastructure in developing countries.

Therefore, it is quite important to observe geographical dimension to have a more closed glimpse on infrastructure. This research article aims at analyzing the impact of economic infrastructure on growth in South Asian countries. Our hypothesis is that a country with higher level of infrastructure has high economic growth in South Asian region.

In methodological terms, we use fixed effects and random effects model to a data set of South Asian countries over a time span of 19 years (2001-2019).

This paper is organized as follows. Following section contains literature review on the relationship of infrastructure and economic growth. Section 3 contains description of variables, model specification and estimation techniques. Empirical results are in section 4. In section 5, authors conclude the paper.

Literature review

The fact cannot be denied that infrastructure is critical for economic growth. It has effect on long-term growth. Besides this growth effect, infrastructure complements other facilities also. When an economy has insufficient infrastructure, other inputs to economy also do not seem to be benefitting

A review of literature on infrastructure and economic growth depicts that this area has been neglected by economists for some time. The evidence of effect of infrastructure on economic growth dates back to Aschauer (1988) and Munnell (1992) who proved this significant relationship. After the work of Aschauer (1988), several researchers started analyzing this direct relationship from different perspectives. Infrastructure facilitates the growth process of economies (Canning & Pedroni, 2004) (Agénor & Moreno-Dodson, 2006) (Straub S. , 2007) (Straub, 2008). Most recent studies tend to report more valid results owing to improved econometric techniques (Romp & Haan, 2007).

Infrastructure investment has a direct impact on productivity as represented by standard growth model. Infrastructure provisions whether public or private enhance the output by fostering other elements in standard growth model (Aghion & Howitt, 1998). On the other hand, there are some indirect means which can affect the accumulation factor of infrastructure like maintenance issues, stability of

private capital, adjustment costs, labor productivity, impact on human development, and economies of scale (Straub, 2008).

Ahmad & Malik (2009) regard infrastructure as an important indicator for growth. Their work stress that infrastructure facilitates many processes; ultimately costs reduction leads to enhanced productivity of economy. Similar notion is also provided by Sahoo, Dash, & Nataraj (2010) that infrastructure improves growth by facilitating production processes, thus cutting down production costs. Among various components of infrastructure, transport infrastructure also tends to show strongly association with economic growth of a country as shown by Saidi et al. (2018).

Infrastructure investments directly play its role in poverty reduction and economic growth. Imran & Niazi (2011) analyzed the effect of infrastructure on Pakistan's economic growth. By using physical indicators of infrastructure, their work reported the positive impact of infrastructure on economic growth of Pakistan. Palei (2015) provided many reasons for the fact that infrastructure paves the way for economic growth.

Researchers have analyzed this relationship in different regions and by using varied estimation techniques. Esfahani & Ramires (2003) estimated infrastructure and growth for 75 countries and found direct relationship between them. This study also reports that improvements at both institutional and organizational level are quite important for better economic outcomes. Egert, Kozluk, & Sutherland (2009) prove relationship between infrastructure and economic growth in OECD countries. On the other hand, Roller & Waverman (2001) analyze telecommunication infrastructure only and show its direct association with growth in OECD countries. Zahra, Azim, & Mahmood (2009) investigated the role of telecommunication infrastructure in lower, middle and high income countries. This work concluded that strong communication channels are necessary for economic activities. Moreover, underdeveloped and developing countries should pay attention towards telecommunication sector in order to cope with modern world challenges. Pradhan et al. (2018) examined ICT infrastructure with growth of G-20 countries. Using vector error correction models, this study confirmed the boosting role of ICT in per capita GDP.

This study aims to investigate the relationship between infrastructure and economic growth in South Asia. A glimpse on this relationship is necessary to understand the scope of infrastructure investments in South Asia.

Methodology

Data source and description of variables

This research article aims at determining the impact of infrastructure on economic growth of eight South Asian countries. Time period of 19 years from 2001-2019 has been covered. Data used in this study is taken from 'World Development Indicators (WDI)' 2019. This work analyzes role of economic infrastructure on economic growth in South Asian countries. Both transport and non-transport

economic infrastructure is considered. Transport infrastructure includes facilities involved in transferring people and goods like air, roads, motorways or railways transport. Non-transport infrastructure facilitates and strengthens production of processes like energy or Information & communication technology (ICT). For the purpose of this article, economic growth is examined from the perspective of both transport and non-transport infrastructure.

For measuring economic growth, GDP per capita is used. Values are taken in current U.S. dollars. This variable is widely used in research for determining economic growth. For independent variables, air transport is chosen for analyzing transport infrastructure in South Asian countries. Two proxies of air transport are used. On the other hand, the impact of non-transport infrastructure is examined by using proxies of both energy and ICT infrastructure. A detailed description of indicators of different forms of infrastructure and definitions are presented in **Table 1**.

Besides dependent and independent variables, three control variables are also used in current study. Gross fixed capital formation, trade and human capital serve the role of control variables in analyzing models. Gross fixed capital formation is the addition of capital in economy and its values are taken as a percentage of GDP. Sum of exports and imports constitute trade and values of this variable are also in percentage of GDP. For human capital, proxy of secondary school education enrollment is used. **Table 2** contains descriptive statistics of variables used in this study.

Component of Infrastructure	**Indicator**	**Definition**
TRANSPORT		
Air	Air transport, registered carrier departures	"Registered carrier departures worldwide are domestic takeoffs and takeoffs abroad of air carriers registered in the country." Values are relative to population (per 100,000 people).
	Air transport, freight	"Air freight is the volume of freight, express, and diplomatic bags carried on each flight stage (operation of an aircraft from takeoff to its next landing), measured in metric tons times kilometers traveled, relative to geographic area." Values are relative to area (per 100,000 sq.km).
ICT		
Telephone	Fixed telephone subscriptions	"Fixed telephone subscriptions refer to the sum of active number of analogue fixed telephone lines, voice-over-IP (VoIP) subscriptions, fixed wireless local loop (WLL) subscriptions, ISDN voice-channel equivalents and fixed public payphones." Values are relative to population (per 100,000 people).
	Mobile cellular subscriptions	"Mobile cellular telephone subscriptions are subscriptions to a public mobile telephone service that provide access to the PSTN using cellular technology. The indicator includes (and is split into) the number of postpaid subscriptions, and the number of active prepaid accounts (i.e. that have been used during the last three months). The indicator applies to all mobile cellular subscriptions that offer voice communications. It excludes subscriptions via data cards or USB modems,

		subscriptions to public mobile data services, private trunked mobile radio, telepoint, radio paging and telemetry services." Values are relative to population (per 100,000 people).
Internet	Internet Users	"Internet users are individuals who have used the Internet (from any location) in the last 12 months. Internet can be used via a computer, mobile phone, personal digital assistant, games machine, digital TV etc." Values are relative to population (per 100,000 people).
ENERGY		
	Electric Power Consumption	"Electric power consumption measures the production of power plants and combined heat and power plants less transmission, distribution, and transformation losses and own use by heat and power plants." Values are in kWh per capita.
	Energy use	"Energy use refers to use of primary energy before transformation to other end-use fuels, which is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport." Values are in kg of oil equivalent per capita.

Table 1: List of indicators of infrastructure and definitions
Source: WDI 2019 (variables as described by database)

Variables/Statistics	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
GDP per capita	120	1826.52	1704.23	119.90	7681.08
Air Transport, Registered departures	105	225.94	381.52	4.74	1533.93
Air transport, Freight	105	167.05	213.96	0	617.92
Fixed Telephone Subscriptions	115	556.22	506.35	1.85	1724.40
Mobile cellular subscriptions	120	4950.27	4574.94	0	20665.62
Internet Users	120	969.83	1101.54	0.46	5446.20
Electric Power	65	405.30	140.24	111.97	765.00
Energy Use	73	437.15	153.84	149.18	864.86
Gross fixed capital formation	107	29.44	12.65	12.33	67.91
Trade	118	69.70	43.70	25.54	204.58
Human Capital	84	7557.69	2279.72	1765.19	12697.79

Table 2: Summary Statistics

Model Specification and panel data estimation

For analyzing the impact of infrastructure on economic growth, in the presence of control variables, following econometric model is formulated:

$$\boldsymbol{Growth_{i,t} = \beta_0 + \beta_2 IF_{i,t} + \beta_2 X_{i,t} + \varepsilon_{i,t}}$$

Where $Growth_{i,t}$ represents GDP per capita, $IF_{i,t}$ represents infrastructure measured by instruments specified above in variables description section. $X_{i,t}$

represents a set of control variables: gross fixed capital formation, trade openness and human capital. Whereas, $\varepsilon_{i,t}$ is the stochastic error term.

For the current study, data of eight South Asian countries have been taken for the period of 2001-2019. As data covers both time-series and cross-sectional aspects, panel data estimation techniques are used. Research employs three standard models for the analysis of panel data: "Pooled ordinary least square (OLS), Fixed Effects Model (FEM), Random Effects model (REM)." (Samargandi, Fidrmuc, & Ghosh, 2015). Therefore, these three models are used in current study for analyzing above specified model. Furthermore, Hausman test is also applied as developed by Hausman (1978). This test is applied for testing the suitable model between fixed effects and random effects estimators. "Stata" software is used for analyzing the results.

Empirical results

Model specified above is used to determine the impact of infrastructure on economic growth in South Asian countries. Ordinary Least square estimation, fixed effects and random effects model are applied. This study analyzes infrastructure by using seven indicators. Analysis is done by putting each indicator separately in regression model along with control variables. In this way, seven different models are analyzed using statistical analysis software stata. Regression results of each of these seven models are presented separately.

Registered departures carried by a country's air transport system tend to be strongly related to economic growth as specified by both OLS and panel models. Results show direct and significant relationship of air transport registered departures with country's economic growth (**Table 3**).

Second instrument of air transport, which is air freight, is found to be a strong predictor of growth in South Asian countries. Both OLS and dynamic panel estimators report it's direct and

Table 3: Association between Air Transport, registered departures and Economic Growth

Econometric Model: $Growth_{i,t} = \beta_0 + \beta_1 AIR1_{i,t} + \beta_2 GFCF_{i,t} + \beta_3 TR_{i,t} + \beta_4 HC_{i,t} + \varepsilon_{i,t}$

Dep. Variable: GDP Growth	**OLS**	**FEM**	**REM**
AIR1	1.609***	1.543***	1.609***
GFCF	-18.370**	-16.317*	-18.370**
TR	4.474	5.538	4.474
HC	32.129	27.262***	34.129***
Constant	- 557.014**	-251.544	-557.015***
Hausman Test		[a]6.30	
Observations	95	95	95
F-Test	191.93***	118.12***	767.73***
R-squared	0.8951	0.8916	0.8951

Notes: OLS: Ordinary Least Square, FEM: Fixed Effects Model, REM: Random Effects Model. *, **, *** shows level of significance at (10, 5 and 1)% respectively. OLS and panel regression statistics are performed in Stata for data estimation. In place of F-test, Wald Chi has been mentioned for REM

estimation. Whereas, GROWTH= GDP per capita, AIR1 = Air Transport Registered Carrier Departures, GFCF = Gross Fixed Capital Formation, TR = Trade Openness, HC = Human Capital. Values of AIRI are calculated per 100,000 populations. Trade openness and gross fixed capital formation are in relation with GDP. Human capital is represented by Secondary school enrollment.
[a]Random effects model is more appropriate.

Table 4: Association between Air Transport, Freight and Economic Growth

Econometric Model: $Growth_{i,t} = \beta_0 + \beta_1 AIR2_{i,t} + \beta_2 GFCF_{i,t} + \beta_3 TR_{i,t} + \beta_4 HC_{i,t} + \varepsilon_{i,t}$

Dep. Variable: GDP Growth	**OLS**	**FEM**	**REM**
AIR2	1.891**	3.297***	1.988**
GFCF	-38.528***	-21.664*	-37.411***
TR	37.875***	37.557***	37.896***
HC	28.793***	1.168	26.803***
Constant	-1237.716***	-212.235	-1165.559***
Hausman Test		[b]20.90	
Observations	90	90	90
F-Test	40.01***	30.16***	156.63***
R-squared	0.6531	0.5853	0.6529

Notes: OLS: Ordinary Least Square, FEM: Fixed Effects Model, REM: Random Effects Model. *, **, *** shows level of significance at (10, 5 and 1)% respectively. OLS and panel regression statistics are performed in Stata for data estimation. In place of F-test, Wald Chi has been mentioned for REM estimation. Whereas, GROWTH= GDP per capita, AIR2 = Air transport, freight, GFCF = Gross Fixed Capital Formation, TR = Trade Openness, HC = Human Capital. AIR2 values are relative to area (per 100,000 sq.km). Trade openness and gross fixed capital formation are in relation with GDP. Human capital is represented by Secondary school enrollment.
[b]Fixed effects model is more appropriate.

significant relationship with economic growth (**Table 4**). It implies that countries should develop their air transport infrastructure in order to mitigate their trade and other business activities. Importance of transport infrastructure is also manifested in previous studies also (Saidi, Shahbaz, & Akhtar, 2018).

World has seen a tremendous change after the revolution of ICT in last few decades. South Asian countries have also seen this dramatic evolution. Despite the fact that some countries face a huge decline in these facilities, telecommunication has played its role in the development of South Asian countries. This study has tested ICT by three instruments- fixed telephone subscriptions, mobile cellular subscriptions and internet users. Both OLS and panel models show that ICT is positively and significantly related to economic growth (**Table 5**, **Table 6**, **and Table 7**). When a country improves its communication infrastructure, its growth is positively and significantly affected. These results are in line with recent studies on ICT and infrastructure (Pradhan, Malik , & Bagchi, 2018).

Importance of energy cannot be denied when talking about the productivity and efficiency of an economy. Without proper energy provisions, it is quite difficult for industries to have efficient and effective production. In the case of South Asian countries, both electric power and energy tend to be significantly related to economic growth. Only in the case of fixed effects model, energy use is not showing significant relationships. All estimations show a positive and direct association between energy and economic growth (**Table 8**, **Table 9**).

Table 5: Association between Fixed Telephone Subscriptions and Economic Growth

Econometric Model: $Growth_{i,t} = \beta_0 + \beta_1 TELEPHONES_{i,t} + \beta_2 GFCF_{i,t} + \beta_3 TR_{i,t} + \beta_4 HC_{i,t} + \varepsilon_{i,t}$

Dep. Variable: GDP Growth	**OLS**	**FEM**	**REM**
TELEPHONES	0.043	0.8991**	0.043
GFCF	-70.305***	-51.461***	-70.305
TR	51.158***	48.425***	51.158***
HC	41.767***	14.056	41.767***
Constant	-1570.182***	-628.206	-1570.182***
Hausman Test		•312.32	
Observations	95	95	95
F-Test	43.51***	31.76***	174.03***
R-squared	0.6591	0.6025	0.6591

Notes: OLS: Ordinary Least Square, FEM: Fixed Effects Model, REM: Random Effects Model. *, **, *** shows level of significance at (10, 5 and 1)% respectively. OLS and panel regression statistics are performed in Stata for data estimation. In place of F-test, Wald Chi has been mentioned for REM estimation. Whereas, GROWTH= GDP per capita, TELEPHONES =Fixed Telephone Subscriptions, GFCF = Gross Fixed Capital Formation, TR = Trade Openness, HC = Human Capital. TELEPHONES values are relative to population (per 100,000 people). Trade openness and gross fixed capital formation are in relation with GDP. Human capital is represented by Secondary school enrollment.
•Difference in coefficients not systematic.

Table 6: Association between Mobile Cellular Subscriptions and Economic Growth

Econometric Model: $Growth_{i,t} = \beta_0 + \beta_1 CELLULAR_{i,t} + \beta_2 GFCF_{i,t} + \beta_3 TR_{i,t} + \beta_4 HC_{i,t} + \varepsilon_{i,t}$

Dep. Variable: GDP Growth	**OLS**	**FEM**	**REM**
CELLULAR	0.146***	0.303***	0.148***
GFCF	-51.615***	-46.381***	-51.566***
TR	44.049***	40.331***	44.084***
HC	17.844**	12.970	17.655**
Constant	-1138.869 ***	-1691.144***	-1138.905***
Hausman Test		[b]8.98	
Observations	95	95	95
F-Test	56.88***	39.37***	219.83***
R-squared	0.7165	0.6824	0.7165

Notes: OLS: Ordinary Least Square, FEM: Fixed Effects Model, REM: Random Effects Model. *, **, *** shows level of significance at (10, 5 and 1)% respectively. OLS and panel regression statistics are performed in Stata for data estimation. In place of F-test, Wald Chi has been mentioned for REM estimation. Whereas, GROWTH= GDP per capita, CELLULAR =Mobile Cellular Subscriptions, GFCF = Gross Fixed Capital Formation, TR = Trade Openness, HC = Human Capital. CELLULAR values are relative to population (per 100,000 people). Trade openness and gross fixed capital formation are in relation with GDP. Human capital is represented by Secondary school enrollment.
[b]Fixed effects model is more appropriate.

Table 7: Association between Internet Users and Economic Growth

Econometric Model: $Growth_{i,t} = \beta_0 + \beta_1 INTERNET_{i,t} + \beta_2 GFCF_{i,t} + \beta_3 TR_{i,t} + \beta_4 HC_{i,t} + \varepsilon_{i,t}$

Dep. Variable: GDP Growth	**OLS**	**FEM**	**REM**
INTERNET	0.583***	0.712***	0.583***
GFCF	-50.592***	-52.196***	-50.592***
TR	36.915***	34.909***	36.915***
HC	16.415***	18.3814***	16.415***
Constant	-656.657**	-814.995***	-656.657**
Hausman Test		[a]1.68	
Observations	95	95	95
F-Test	75.30***	42.16***	301.18***
R-squared	0.7699	0.7653	0.7699

Notes: OLS: Ordinary Least Square, FEM: Fixed Effects Model, REM: Random Effects Model. *, **, *** shows level of significance at (10, 5 and 1)% respectively. OLS and panel regression statistics are performed in Stata for data estimation. In place of F-test, Wald Chi has been mentioned for REM estimation. Whereas, GROWTH= GDP per capita, INTERNET =Internet Users, GFCF = Gross Fixed Capital Formation, TR = Trade Openness, HC = Human Capital. INTERNET values are relative to population (per 100,000 people). Trade openness and gross fixed capital formation are in relation with GDP. Human capital is represented by Secondary school enrollment.

[a]Random effects model is more appropriate.

Table 8: Association between Electric Power Consumption and Economic Growth

Econometric Model: $Growth_{i,t} = \beta_0 + \beta_1 ELECTRIC_{i,t} + \beta_2 GFCF_{i,t} + \beta_3 TR_{i,t} + \beta_4 HC_{i,t} + \varepsilon_{i,t}$

Dep. Variable: GDP Growth	**OLS**	**FEM**	**REM**
ELECTRIC	1.950***	2.046***	1.950***
GFCF	-61.232***	-68.033***	-61.232***
TR	-6.880	-10.203	-6.879
HC	40.571***	44.091***	40.571***
Constant	-87.278***	-3.899***	-87.278
Hausman Test		[b]11.10	
Observations	56	56	56
F-Test	100.81***	63.07***	403.23***
R-squared	0.8877	0.8863	0.8877

Notes: OLS: Ordinary Least Square, FEM: Fixed Effects Model, REM: Random Effects Model. *, **, *** shows level of significance at (10, 5 and 1)% respectively. OLS and panel regression statistics are performed in Stata for data estimation. In place of F-test, Wald Chi has been mentioned for REM estimation. Whereas, GROWTH= GDP per capita, ELECTRIC =Electric Power Consumption, GFCF = Gross Fixed Capital Formation, TR = Trade Openness, HC = Human Capital. ELECTRIC values are in kWh per capita. Trade openness and gross fixed capital formation are in relation with GDP. Human capital is represented by Secondary school enrollment.

[b]Fixed effects model is more appropriate.

Table 9: Association between Energy Use and Economic Growth

Econometric Model: $Growth_{i,t} = \beta_0 + \beta_1 ENERGY_{i,t} + \beta_2 GFCF_{i,t} + \beta_3 TR_{i,t} + \beta_4 HC_{i,t} + \varepsilon_{i,t}$

Dep. Variable: GDP Growth	**OLS**	**FEM**	**REM**
ENERGY	1.671***	1.586***	1.671***
GFCF	-22.571**	-19.730	-22.571**
TR	11.637***	10.194*	11.637***
HC	28.630***	26.635***	28.630***
Constant	-1130.193***	-999.593***	-1130.193***
Hausman Test		[a]0.63	
Observations	59	59	59
F-Test	26.94***	12.20***	107.76***
R-squared	0.6662	0.6660	0.6662

Notes: OLS: Ordinary Least Square, FEM: Fixed Effects Model, REM: Random Effects Model. *, **, *** shows level of significance at (10, 5 and 1)% respectively. OLS and panel regression statistics are performed in Stata for data estimation. In place of F-test, Wald Chi has been mentioned for REM estimation. Whereas, GROWTH= GDP per capita, ENERGY =Energy Use, GFCF = Gross Fixed Capital Formation, TR = Trade Openness, HC = Human Capital. ENERGY values are in kg oilt per capita. Trade openness and gross fixed capital formation are in relation with GDP. Human capital is represented by Secondary school enrollment.

[a]Random effects model is more appropriate.

Among the control variables, gross fixed capital formation is not found to be related to economic growth. Trade openness and human capital is directly and significantly related to growth of countries. Import and exports show the strong economic position of countries. While human capital is always considered a strong predictor of economic growth.

Results of this study are consistent with existing theories (Roller & Waverman, 2001) (Goel, 2003) (Sahoo, Dash, & Nataraj, 2010) (Imran & Niazi, 2011) (Palei, 2015) which report the positive and significant relationship between used instruments of infrastructure and economic growth.

Conclusion

In this study, the impact of infrastructure on economic growth is discussed in South Asian countries. Our findings suggest that infrastructure is a strong predictor of economic growth. With the growth of different kinds of infrastructure, a country enjoys a strong economic position. These results held in panel estimations and are robust to varied techniques and different measures of infrastructure.

An important implication of this research article is that it has considered both economic and social infrastructure in it analysis. Inclusion of both components in study provides more comprehensive results and guide policy holders to formulate policies for better living condition of people. In turn, economic growth of country will be strengthened.

Outcomes of this article will certainly help in macro-economic planning. South Asian countries should direct their investments towards infrastructure

projects. Results of this study open new dimensions for investment also. Countries should direct their investments towards modern infrastructure and energy-efficient technologies that can positively affect their economic growth. Future research should be done in individual country of South Asia to help policy makers in their definite area.

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