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Critical evaluation of China's universal service policy: Toward a harmonious online nation

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ABSTRACT

In response to the Communist Party's call to build a harmonious society, China initiated its universal service program in 2004. This article aims to provide a data-based analysis of the effectiveness of China's digital divide policy. While China has achieved significant progress in narrowing the interprovincial and urban-rural digital disparities at the national level, the advancement of the penetration rate has lagged behind the expansion of the network. In addition, as this study shows, not all provinces are making progress at the same rate. Laying of more fiber and erection of more towers have diminishing effects on narrowing China's digital divide. To achieve a harmonious online nation, as sought by the Party, this study recommends that the Chinese regulators make a shift from the top-down infrastructure-centered approach to an end-user-oriented approach.

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China; development; digital divide; information; universal service

> *What I have heard is that the head of a state or a noble family worries not about underpopulation but about uneven distribution, not about poverty but about instability. For where there is even distribution, there is no such thing as poverty; where there is harmony, there is no such thing as underpopulation; and where there is stability, there is no such thing as overturning* (Confucius, The Analects 1998, 138-139)

Introduction

In the 1950s, soon after the Chinese Communist Party took power, it used the expression "upstairs and downstairs, electric lights and telephone" to evoke the vision of the good it promised to bring to Chinese people. However, before the corporatization of the telecommunications sector in the late 1990s, having a home phone line was considered to be a political privilege. Ironically, the exponential growth of the telecommunications network in the early 2000s worsened both the rural-urban and coastal-inlands divides (Harwit 2004; Knight and Song 1999; Loo and Ngan 2012; Zhao 2007). Subsequently, in response to the Party's call to build a harmonious society, China initiated its universal service program in 2004.

Corresponding to these developments, with a growing interest in research on China's telecommunications, scholars from various disciplines have generated many publications on its universal service initiatives. In addition to its rapid growth, they are drawn to China's unique model of development, which arguably could be used to inform policies in other developing countries. These existing studies have mostly emphasized the institutional factors that influence the manner in which universal service programs operate in China. Interestingly, few studies have provided concrete statistical evidence on the actual progress made in this area. This article aims to add to the existing literature by providing a quantitative evaluation of the evolution of China's digital divide over the past 15 years and critically appraising the effectiveness of China's universal service program. In addition to the usual national urban-rural dichotomy, this study takes the level of analysis down to the interprovincial level, which is largely neglected by existing studies. Through this evidence-based analysis, lessons drawn from China could potentially be useful to both developing and developed countries.

Evolution of China's universal service program

China's exponential growth in the telecommunications sector in the 1990s posed serious challenges to service provision in rural areas and, in fact, made development more uneven between urban and rural areas

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(Harwit 2004; Loo and Ngan 2012; Zhao 2007). During this period, both the rural-urban and coastal-inland divides widened due to the central government's policy of concentrating financial resources on certain cities and regions (Knight and Song 1999; Loo and Ngan 2012). In 2002, the Hu (President) and Wen (Premier) administration initiated a New Socialist Countryside campaign to alleviate China's widening rural-urban divides, in which the improvement of rural communications was one of the top considerations (Shi 2008). In 2000, universal service was formally written into the Telecommunications Regulations of the People's Republic of China.

Since then, China has taken an incremental approach to addressing the digital divide, maintaining a constantly updated program called Telecommunications to Every Village (hereinafter referred to as the Village Access program) to connect its vast rural areas (Liu and Jayakar 2012; Shi 2008; Xia 2016a, 2016b). The expansion of the Village Access program was divided into three stages by the Ministry of Industry and Information Technology (MIIT), which is China's telecommunications regulator, as depicted in Table 1.

In the Village Access program, the Chinese government took a simple yet effective approach by assigning tasks to the country's state-owned carriers, based on their respective revenues, profits, and the geographical locations of their networks. The statistics show that China has achieved the goals set in the Village Access program. One hundred percent of administrative villages had telephone connections by 2010. Further, 96.7% of administrative villages had access to broadband networks by 2016 (see Figure 1).

Since 2016, broadband has been officially added to the menu of China's universal service program, with a focus on extending the broadband network to rural villages through the Broadband Countryside project (State Council 2013a). China initiated a national campaign called Broadband China to boost broadband development in 2013. Several major national policies have been issued, which have set specific goals for infrastructure development and initiated projects to boost information consumption (Liu 2016a, 2017).[1] Balanced development across different regions is listed as one of the key tasks in the Broadband China initiatives. The central government set the goal of connecting 98% of administrative villages to the broadband network by 2020 (see Table 2). In this stage, instead of being compulsorily assigned certain tasks, telecommunications carriers and other interested companies are encouraged to bid for government subsidies. In this fashion, several pilot projects have been launched. For example, in 2014, the MIIT, the National Development and Reform Commission (NDRC), and the Ministry of Finance (MOF) issued a joint call for applications in a program in which the successful applicant would receive central government subsidies to build a broadband network in 100 selected counties in five western provinces (General Office of the NDRC, General Office of the MOF, and General Office of the MIIT 2014). In 2017, the NDRC started a new pilot project subsidizing the buildup of the fiber to the home (FTTH) access network in rural areas (General Office of the NDRC 2017).

Dimensions of universal service

Sawhney and Jayakar (1999) identified three dimensions of universal service, namely, territorial expansion, demographic expansion, and layered expansion. While not mutually exclusive, each mode calls for the use of different policy instruments (infrastructure investment in territorial expansion and targeted consumer subsidies in demographic expansion, for example) and different performance metrics (geographic coverage in territorial expansion and teledensity in demographic expansion, for example). Sawhney and Jayakar (1999) show how the U.S. moved through these stages in the course of the historical evolution of universal service programs in that country.

In China, investment in telecommunications infrastructure in rural areas has been regarded as an important engine for rural growth and is thereby taken to be important for achieving a more harmonious economy, as well as for the simultaneous development of both urban and rural areas (Xia and Lu 2008). Jayakar and Liu (2014) argue that to gain greater economic impact, the Chinese government has

Table 1. China's village access program.

Stages	Time period	Targets
Stage 1	2004–2005	• Achieve 95% administrative village[4] telephone coverage
Stage 2	2006–2010	• Achieve nearly 100% administrative village telephone coverage • Achieve 100% township broadband coverage • Extend the telephone network from administrative village to natural village
Stage 3	2011–2015	• Achieve 95% administrative village broadband coverage • Continue to extend communications network to natural village

Source: Ministry of Information Technology.

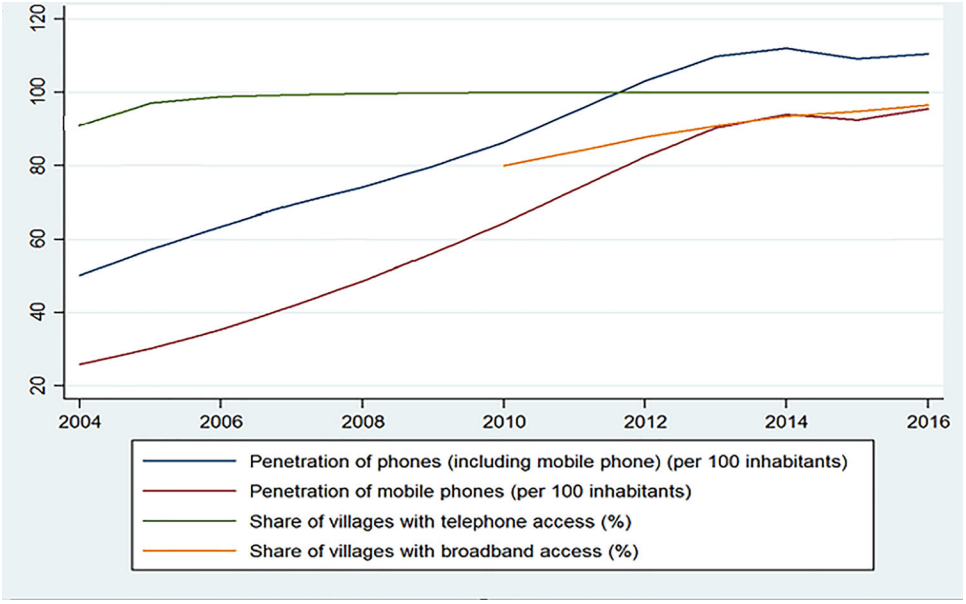

Figure 1. Key indicators in China's telecommunications development.
Data source: China Statistical Yearbook

Table 2. Major objectives of the Broadband Countryside Project.

Indicators	Unit	2013	2015	2020
Number of households with wireline broadband service (urban/rural)	million	210 (160/50)	270 (200/70)	400 (n/a, n/a)
Household wireline broadband penetration (urban/rural)	%	40 (55/20)	50 (65/30)	70 (n/a, n/a)
Broadband connection speed in rural areas	Mbps	4	4	12
Broadband penetration for administrative villages	%	90	95	>98

Source: State Council (2013a).

preferred to place greater emphasis on territorial and layered expansion, largely neglecting the demographic expansion of universal services. While it is officially claimed that all the goals set by the government have been met, few scholarly studies have looked for concrete statistical evidence of such progress. In fact, with regard to urban-rural disparity in the Internet penetration rate, a recent study has found that, while disparities have decreased at the provincial level, the rural-urban gap has actually widened from 2005 to 2014 (Loo and Wang 2017). In the following sections, following the Sawhney and Jayakar (1999) analytical framework, a data-based evaluation of the evolution of China's digital divide in the past 15 years is conducted.

Data analysis

The data used in this article have been compiled from the China Statistical Yearbooks by the National Bureau of Statistics of China and the China Broadband Speed Reports by the Broadband Development Alliance (BDA).[2] The data are aggregated at the provincial level. The period covered in the measurements varied because of limited data availability.

Interprovincial disparities

Coefficient of variance (CV) statistics were used to measure the interprovincial disparities. The coefficient of variation (CV) and standard deviation (SD), two statistical measures of the dispersion of a distribution, are two common indicators for measuring inequalities in many fields, including the field of information and communication technologies for development (ICT4D) (Corrocher and Ordanini 2002; Liu, Fang, and Sun 2017; Lucendo-Monedero, Ruiz-Rodríguez, and González-Relaño 2019). The coefficient of variation was chosen over the standard deviation because of its scale invariant properties. Scale-invariance is desirable because in enables the comparison of inequality across different quantities that are measured on different scales, such as telephone penetration and Internet penetration, as well as the coverage, penetration, and speed of broadband. A rising CV for a measurement implies that the gap between provinces on that measure has widened, and vice versa.

Table 3. Development in telephone penetration and Internet penetration rate at provincial level, 2010–2017.

		Unit	2010	2011	2012	2013	2014	2015	2016	2017
Telephone	Mean	%	90.80	97.73	106.69	111.58	114.88	111.01	112.55	118.32
	Median	%	86.41	94.02	97.90	103.16	106.92	105.58	108.15	112.38
	Cv		0.33	0.28	0.28	0.27	0.27	0.27	0.24	0.21
Internet	Mean	%	35.68	38.95	42.70	46.47	48.29	51.24	53.65	n/a
	Median	%	33.30	36.90	40.30	43.90	45.70	49.30	51.60	n/a
	Cv		0.36	0.32	0.28	0.25	0.24	0.22	0.19	n/a

Data source: National Bureau of Statistics of China.

First, two indicators, namely, telephone penetration rate and Internet penetration rate, were examined. The telephone penetration rate refers to the number of phone lines (including both fixed-line and mobile phones) per 100 inhabitants. The Internet penetration rate refers to the percentage of Internet users who have accessed the Internet in the past six months (including all access modes) per 100 inhabitants. Table 3 shows the mean, median, and CV of these two measurements at the provincial levels from 2010 to 2017. While the average level for both telephone penetration and Internet penetration have steadily increased, the disparities have reduced in a way that the disparity in Internet penetration has dropped at a faster rate than that of the disparity in telephone penetration.

We then proceeded to examine the provincial level disparity in wireline broadband development. Mobile broadband is not included in this part of the analysis. Three measurements were used in our study to reflect the different dimensions of broadband development, namely, availability of infrastructure (coverage), service penetration (penetration), and quality of service (speed). The broadband availability refers to the number of available broadband access points installed by operators per 100 inhabitants. The types of access points include xDSL (digital subscriber line), FTTX (fiber to the x), LAN (local area network), and other fixed-line access technologies. The service penetration refers to the number of in-use broadband access points per 100 inhabitants. As connection quality has become an important dimension of the digital divide, speed (as measured by the average download speed, Mb/s) is included in our analysis.

Table 4 shows the mean, median, and CV of these three dimensions of broadband development at the provincial levels from 2007 to 2017. The average levels for coverage, penetration, and speed have all undergone a remarkable increase. Moreover, as the CV measure indicates, the provincial divide has narrowed in all three dimensions. However, it is worthwhile to note that the divide in penetration has narrowed less than both the coverage and speed divides since 2013, when the Broadband China campaign was initiated.

Urban-rural disparities

In this section, urban-rural disparity is examined to understand how it has evolved over the years at both the national and provincial levels. Data on two measures for urban and rural areas, namely, landline telephone penetration and fixed-line broadband penetration, were collected and evaluated. Data on landline telephone penetration were available for the period of 2005–2017, while data on broadband penetration were available for the period of 2011–2017. The urban (or rural) landline telephone penetration was defined as the number of urban (or rural) landline telephone subscribers per 100 inhabitants in urban (or rural) areas. The urban (or rural) broadband penetration was defined as the number of urban (or rural) broadband subscribers per 100 inhabitants in urban (or rural) areas.

Urban-Rural disparities in landline telephone penetration. As Figure 2 shows, at the national level, over the last ten years, the landline telephone penetration for both the urban and rural areas saw a decreasing trend. The decline in urban areas occurred earlier than that in rural areas, and the magnitude was also greater for urban areas. However, the landline telephone penetration for urban areas in 2017 was still higher than the highest level of landline telephone penetration for rural areas during the study period. Although the disparity in landline telephone penetration between urban and rural areas has been consistently narrowed, this process has significantly slowed since 2010.

Table 5 shows the urban-rural disparities in landline telephone penetration at the provincial level. Comparing the year 2017 to 2005, the urban-rural disparities in most provinces have narrowed, with a percent change ranging from −10% to −145%. By comparing the ranks in 2005 to those in 2017, we can compare the progress individual provinces have made. The first thing to note is that the top ten listed provinces in 2005 witnessed a major change by 2017, with six provinces dropping to the middle or even the bottom of the list, indicating that these provinces have made less progress in narrowing the urban-rural divide in landline telephone penetration compared to

Table 4. Development of broadband (coverage, penetration, and speed), 2007–2017.

		Unit	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Coverage	mean	(%)	6.77	8.57	10.54	13.93	17.29	24.30	26.56	29.58	41.11	51.26	56.18
	median	(%)	4.70	6.49	8.29	12.81	15.89	20.42	24.04	27.24	36.73	47.05	51.97
	cv		0.82	0.69	0.60	0.52	0.41	0.47	0.41	0.37	0.36	0.27	0.26
Penetration	mean	(%)	5.30	6.52	8.04	9.43	10.96	12.58	13.42	14.23	17.78	20.25	23.98
	median	(%)	3.60	4.98	6.45	8.02	9.88	11.42	12.80	13.32	16.41	19.23	23.31
	cv		0.79	0.69	0.61	0.52	0.43	0.37	0.34	0.32	0.31	0.29	0.26
Speed	mean	(Mb/s)	n/a	n/a	n/a	n/a	n/a	n/a	2.79	3.53	4.96	9.34	12.88
	median	(Mb/s)	n/a	n/a	n/a	n/a	n/a	n/a	2.73	3.31	4.79	9.20	13.12
	cv		n/a	n/a	n/a	n/a	n/a	n/a	0.14	0.16	0.13	0.12	0.09

Data source: National Bureau of Statistics of China; Broadband Development Alliance.

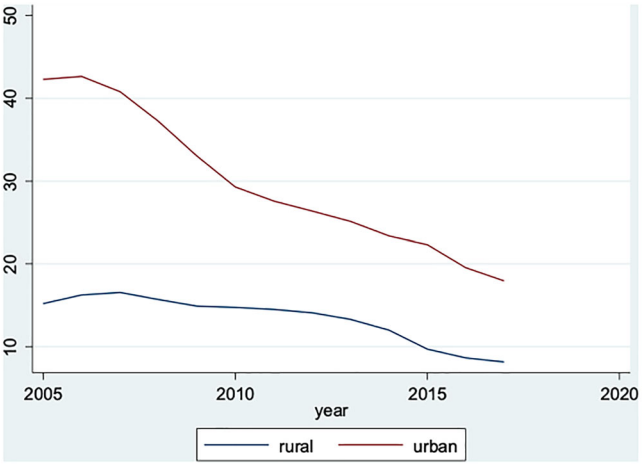

Figure 2. Urban-rural disparities in landline telephone penetration, 2005–2017.
Data source: National Bureau of Statistics of China

their fellow provinces. However, the provinces at the bottom of the list in 2005, which evidenced the greatest urban-rural divide in landline telephone penetration rates, remained much unchanged from 2005 to 2017, with the notable exceptions of Hainan (ranked 24th in 2005 and 6th in 2017) and Fujian (ranked 25th in 2005 and 3rd in 2017).

Spearman's rank correlation coefficient was computed to assess the relationship between the urban-rural disparities in landline telephone penetration in 2005 and 2017. As shown in Table 5, the Spearman correlation was 0.36, with a *p*-value of 0.05, indicating that provinces with a higher ranked urban-rural disparity in landline telephone penetration in 2005 tended to have a higher ranked urban-rural disparity in landline telephone penetration in 2017.

Urban-rural disparities in broadband penetration. As Figure 3 shows, at the national level, the broadband penetration for both urban and rural areas saw a steadily increasing trend during the study period. The trend lines for the urban and rural areas appear to be similar. The disparity in broadband penetration between urban and rural areas remained at approximately the same level before 2014 and slightly widened after 2015. In addition, the highest broadband penetration level for rural areas in 2017 did not equal the lowest broadband penetration level for urban areas in 2011, suggesting that despite pronounced development, the rural areas are still several years behind the urban areas with regard to broadband penetration.

At the provincial level, comparing the results from 2011 to those of 2017, the urban-rural disparities in most provinces have widened, with percent increases ranging from 2% to 177%. Only six provinces saw a narrowed urban-rural divide, with the broadband penetration rate decreasing by 1% to 68%. As shown in Table 6, the top ten listed provinces remained much unchanged from 2011 to 2017. The provinces of Zhejiang (ranked 2nd in 2011 and 14th in 2017) and Guangdong (ranked 4th in 2011 and 15th in 2017) dropped out of the top ten list, indicating that these two provinces made less progress in narrowing the urban-rural divide in broadband penetration compared to their fellow provinces. Interestingly, the provinces of Zhejiang and Guangdong were two of the most prominent early movers in IT development in China. In contrast, the bottom 10 listed provinces in 2011, which exhibit the greatest urban-rural divide in broadband penetration rates, witnessed a major change when compared to the 2017 list, with six of these ten provinces jumping up to the middle or even the top range of the list. The province of Hebei, which ranked 23rd in 2011, successfully achieved the rank of 6th in 2017. Most of the provinces in the middle section, which are also located in the middle section of China geographically, were pushed further down the list, except the provinces of Heilongjiang and Neimenggu.

Spearman's rank correlation coefficient was computed to assess the relationship between the urban-rural disparities in broadband penetration in 2011 and 2017. As shown in Table 6, the Spearman correlation was 0.55, with a *p*-value of 0.002, indicating that provinces with a higher ranked urban-rural disparity in broadband penetration in 2011 tended to have a

Table 5. Urban-rural disparities in landline telephone penetration.

	2005		2017				Rank correlations
Province	Disparity (%)	Rank	Disparity (%)	Rank	Widened or narrowed	Percent of change	2005 vs. 2017
Shandong	7.7	1	4.3	4	Narrowed	−44%	rho = 0.36
Zhejiang	13.9	2	12.6	21	Narrowed	−10%	$p = 0.05$
Anhui	14.3	3	6.3	9	Narrowed	−56%	
Hunan	17.9	4	5.8	8	Narrowed	−67%	
Jiangxi	18.0	5	5.0	5	Narrowed	−72%	
Hebei	19.0	6	11.9	20	Narrowed	−37%	
Jilin	19.6	7	15.9	26	Narrowed	−19%	
Chongqing	20.9	8	10.3	18	Narrowed	−51%	
Liaoning	21.7	9	14.9	25	Narrowed	−31%	
Heilongjiang	23.5	10	13.3	22	Narrowed	−44%	
Guangdong	24.0	11	7.2	11	Narrowed	−70%	
Hubei	25.2	12	7.4	12	Narrowed	−71%	
Guangxi	25.5	13	5.7	7	Narrowed	−78%	
Henan	25.9	14	6.3	10	Narrowed	−76%	
Ningxia	27.2	15	11.6	19	Narrowed	−57%	
Guizhou	27.7	16	9.9	16	Narrowed	−64%	
Beijing	27.8	17	−12.6	1	Narrowed	−145%	
Shaanxi	28.0	18	13.8	24	Narrowed	−51%	
Nei Mongol	28.3	19	10.2	17	Narrowed	−64%	
Jiangsu	28.7	20	−2.1	2	Narrowed	−107%	
Shanxi	28.7	21	9.5	14	Narrowed	−67%	
Yunnan	28.9	22	8.9	13	Narrowed	−69%	
Sichuan	32.0	23	9.5	15	Narrowed	−70%	
Hainan	32.2	24	5.1	6	Narrowed	−84%	
Fujian	32.8	25	−1.7	3	Narrowed	−105%	
Qinghai	37.3	26	25.7	29	Narrowed	−31%	
Gansu	43.2	27	13.4	23	Narrowed	−69%	
Xinjiang	50.9	28	22.8	28	Narrowed	−55%	
Tianjin	52.9	29	21.7	27	Narrowed	−59%	
Shanghai	54.0	30	n/a		n/a	n/a	
Xizang	83.1	31	45.3	30	Narrowed	−45%	
National	27.1		9.8		Narrowed	−64%	

Data source: National Bureau of Statistics of China.

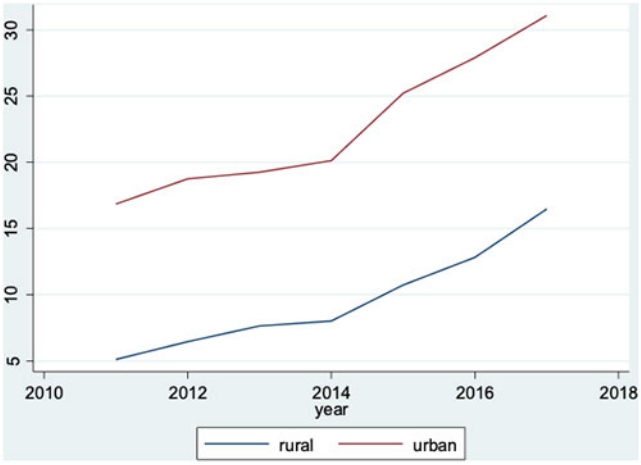

Figure 3. Urban-rural disparities in broadband penetration, 2011–2017.
Data source: National Bureau of Statistics of China.

higher ranked urban-rural disparity in broadband penetration in 2017.

Understanding the changing disparities

In this section, factors that contribute to the observed interprovincial disparities are explored. Regression analyses were performed to test the effects of several explanatory variables on telephone penetration and Internet penetration. The selection of the explanatory variables was based on the existing literature (Vicente and López 2011) and restricted by data availability. We estimated an econometric model of the following general form:

$$y_{it} = X_{it}\beta + \varepsilon_{it}$$

where y is a vector of the dependent variables (telephone penetration, Internet penetration, urban-rural disparities in landline telephone penetration, and urban-rural disparities in broadband penetration) for each of the provinces; X is a matrix of the provincial values of the explanatory variables, including ECO (GDP per capita), AGE (number of the population aged 65 or older per 100 labor force), EDU (percent of illiteracy in the population over the age of 15), and URB (percent of the population in urban areas, as a measure of urbanization and an additional variable in explaining urban-rural disparities); vector ε is the corresponding disturbance term; and β is the vector of coefficients to be estimated.

The summary statistics are provided in Table 7.

Table 6. Urban-rural disparities in broadband penetration.

	2011		2017				Rank correlations
Province	Disparity (%)	Rank	Disparity (%)	Rank	Widened or narrowed	Percent of Change	2011 vs. 2017
Beijing	−9.7	1	0.9	2	Widened	−110%	rho = 0.55 p = 0.002
Zhejiang	−3.2	2	15.0	14	Widened	−563%	
Jiangsu	2.1	3	−10.6	1	Narrowed	−593%	
Guangdong	5.6	4	15.6	15	Widened	177%	
Fujian	8.4	5	2.6	3	Narrowed	−68%	
Anhui	8.5	6	12.4	7	Widened	46%	
Jiangxi	8.7	7	12.5	8	Widened	44%	
Hainan	10.8	8	7.3	4	Narrowed	−32%	
Shandong	11.0	9	7.4	5	Narrowed	−33%	
Hunan	11.0	10	13.1	10	Widened	19%	
Gansu	11.3	11	17.2	20	Widened	52%	
Henan	12.2	12	19.6	21	Widened	60%	
Ningxia	12.3	13	29.1	29	Widened	137%	
Hubei	12.3	14	17.0	19	Widened	38%	
Yunnan	12.8	15	26.4	27	Widened	106%	
Guizhou	12.9	16	19.7	22	Widened	52%	
Heilongjiang	13.2	17	13.0	9	Narrowed	−1%	
Jilin	13.2	18	21.3	26	Widened	62%	
Nei Mengol	13.2	19	14.1	12	Widened	7%	
Sichuan	13.2	20	15.9	17	Widened	20%	
Liaoling	13.3	21	13.6	11	Widened	2%	
Shaanxi	13.9	22	15.9	16	Widened	14%	
Hebei	14.2	23	7.4	6	Narrowed	−48%	
Qinghai	14.5	24	28.4	28	Widened	95%	
Chongqing	14.6	25	15.0	13	Widened	3%	
Xinjiang	15.0	26	20.8	25	Widened	39%	
Guangxi	15.2	27	16.0	18	Widened	5%	
Tianjin	16.8	28	19.8	23	Widened	18%	
Shanxi	17.8	29	20.6	24	Widened	16%	
Shanghai	n/a		n/a		n/a		
Xizang	n/a		n/a		n/a		
National	11.8		14.6		Widened	23%	

Data source: National Bureau of Statistics of China.

The regression models were fitted with both the fixed-effects estimator and the random-effects estimator, and then a robust version of Hausman's specification test was run to compare the two estimators. The random-effects estimator was preferred. The results from the models with robust standard errors are reported in Table 8. The models fit the data well, especially for the telephone equation (with an adjusted R^2 of 67%) and the Internet equation (with an adjusted R^2 of 72%). The variance inflation factors (VIFs) for the predictors are all below 1, suggesting no multicollinearity, except for ECO (VIF less than 5, suggesting moderate correlation). The results showed that ECO (GDP per capita) had a significant positive effect both on telephone penetration ($\beta = 0.67$, $p < 0.001$) and Internet penetration ($\beta = 0.51$, $p < 0.001$). EDU (percent of illiteracy in the population over the age of 15) also significantly predicted Internet penetration ($\beta = 0.26$, $p < 0.05$). No significant effect of AGE (number of the population aged 65 or older per 100 labor force) was found for telephone or Internet penetration.

With regard to urban-rural disparity, the results showed that ECO (GDP per capita) had a significant negative effect ($\beta = -0.30$, $p < 0.001$) on urban-rural disparity in landline telephones, implying that provinces with a higher GDP per capita tend to have a lower urban-rural disparity in landline telephone penetration. In other words, each additional 1000 Yuan in GDP per capita is associated with a decrease of 0.3 percent on the urban-rural disparity in landline telephone penetration, with all other variables held constant. Both AGE (number of the population aged 65 or older per 100 labor force) ($\beta = 1.51$, $p < 0.01$) and EDU (percent of illiteracy in the population over the age of 15) ($\beta = 0.80$, $p < 0.001$) were found to have a significant positive effect on urban-rural disparity in landline telephones, implying that provinces with higher levels of aging population and illiteracy are associated with higher levels of urban-rural disparity in landline telephone penetration. On the other hand, the model for urban-rural disparity in broadband showed comparatively less explanatory power, with an adjusted R^2 of 24%. EDU (percent of illiteracy in the population over the age of 15) was the only variable in the model that showed a significant effect ($\beta = 0.26$, $p < 0.05$), implying that illiteracy is positively related to urban-rural disparity in broadband.

Table 7. Summary statistics.

Variables	Unit	Mean	SD	Min	Max
Telephone penetration	%	110.39	28.93	67.14	228.09
Internet penetration	%	46.88	12.46	24.20	77.80
Urban-rural disparity in landline telephone	%	12.76	12.16	−25.39	55.84
Urban-rural disparity in broadband	%	13.33	8.19	−15.28	50.64
ECO	1000 Yuan	50.24	23.52	16.41	128.99
AGE	%	13.15	2.96	6.70	20.60
EDU	%	6.18	6.31	1.23	41.19
URB	%	55.58	13.38	22.72	89.61

Table 8. Regression results.

	Telephone penetration		Internet penetration		Urban-rural disparity in landline telephone		Urban-rural disparity in broadband	
	Coef.	Robust SE	Coef.	Robust SE	Coef.	Robust SE	Coef.	Robust SE
ECO	0.67***	0.15	0.51***	0.06	−0.30***	0.05	0.08	0.10
AGE	−0.55	0.84	0.51	0.41	1.51**	0.58	0.57	0.40
EDU	−0.27	0.44	0.26*	0.12	0.80***	0.22	0.26*	0.12
URB					−0.14	0.26	−0.08	0.24
CONSTANT	85.52***	11.05	13.86*	5.63	11.36	8.85	4.91	7.83
N	217		186		370		209	
Adjusted R^2	0.67		0.72		0.42		0.24	

Notes:
*$p < 0.05$,
**$p < 0.01$,
***$p < 0.001$.

Discussion

There are some possible scenarios that result from a nation's universal service program. In the ideal scenario, divides are narrowed at all regions, and those originally less-developed regions advance at a faster pace. In the unsatisfactory scenario, the original divides become wider. China seems to fall somewhere between these two extremes.

Building a harmonious networked country: With a focus on territorial expansion

Overall, territorial expansion appears to have the highest priority in China's existing universal service program. The recognition of the widening urban-rural divide in the 1980s, when the telecommunication sector was given a priority and began to expand, urged the Chinese government to initiate the Telecommunications to Every Village program, which aims to expand the telecommunications network, first to administrative villages and then to the smaller natural villages. As shown in the previous sections, China has successfully connected nearly all rural villages to telephone and broadband networks nationwide.

During its territorial expansion, China has also invested in the dimension of layered expansion by gradually adding extra services to the universal service offering. The Telecommunications to Every Village program has evolved from plain telephone service to broadband. In addition, China has attempted to upgrade its universal service beyond a mere connection to a service that incorporates information (content), namely, an informatization service (Hanna, Qiang, Bhavnani, Kimura, and Sudan 2009; Liu 2012; Ting and Yi 2013). For example, the Information to the Countryside program aims to provide one information station (website) and one information database for every township, as well as one information collection point and one online page for every administrative village.

Based on their analysis of the U.S., Sawhney and Jayakar (1999) suggest that once a network has achieved extensive network coverage through territorial expansion, the focus of the universal service will change to demographic expansion. However, thus far, China has largely neglected demographic expansion. There has been hardly any specific universal service program directly targeting end-users. Particularly in some of China's poorest rural areas, individuals' inability to afford telecommunications service might become a more serious constraint than ensuring an adequate supply of telecommunications services by mandating state-owned carriers to expand the network. It seems that the Chinese government has, to some extent, realized the issue of affordability. In its recent national broadband plan, while no specifics have been given, the government has called upon state-owned carriers to lower their charges for broadband access (General Office of the State Council 2015).

Interprovincial divide: A neglected issue in policy design

Because bridging the urban-rural digital divide is the central task of the Chinese government, China has

not devised any specific policy or program to address the interprovincial digital disparity. This study investigates the interprovincial broadband digital divide in three dimensions and reveals that coverage, penetration, and speed gaps are all narrowing. This finding is consistent with those of other studies (Loo and Ngan 2012; Loo and Wang 2017).

However, while all three indicators of broadband disparity are showing narrowing of disparities, they also show that rate of narrowing for broadband penetration slowed down around 2013 compared to the other two – coverage and speed. Existing studies have generally agreed that, while supply-side policies can initially stimulate a higher take-up rate, only demand-side policies seem to have positive effect after broadband penetration reaches a certain degree (Belloc, Nicita, and Rossi 2012; Dias 2012; Preston and Cawley 2008; Shin and Jung, 2012; Shin and Kweon 2011). It appears that China's continuous investment in broadband infrastructure had a diminishing effect after 2013, when the market seemingly entered the saturation stage (Liu 2017). Indeed, while mandating that state carriers lay down more optical fibers would continue to expand coverage and improve the quality of connection, doing so would not necessarily lead to a higher adoption rate. Given the immense interprovincial diversities, a more customized approach might be preferable to a unified national policy. For example, for those provinces that have entered the saturation stage of telephone or broadband development, the emphasis of universal service policy shall be placed on the demand side.

Urban-rural divide: Mission accomplished?

China's universal service program has a predominant focus on connecting rural areas. The present analysis shows that, at the national level, in terms of telephone penetration, after the initial rapid catch-up process, the urban-rural disparity has remained approximately constant since 2010. Further, the introduction of a national broadband plan has had a limited impact on narrowing the urban-rural divide in terms of broadband penetration. The disparity remained roughly at the same level before 2014 and even widened after 2015. Both telephone penetration and broadband penetration levels for the urban areas in 2017 were still higher than the highest levels for both penetration types in the rural areas during the study period, indicating that the rural areas are still several years behind the urban areas.

In addition, the within-province urban-rural divide seems to be widening in most provinces, particularly with regard to broadband adoption. As evidenced in our data, only five provinces have narrowed their urban-rural broadband divide since 2011. Overall, our analysis shows that provinces that previously ranked higher in urban-rural disparities tended to continue to rank higher in 2017. Particularly, longtime less-developed provinces in the northwest and southwest regions have experienced the most severe widening among all provinces. Interestingly, some coastal provinces, such as Zhejiang and Guangdong, have also experienced some degree of widened urban-rural disparity. To that end, the worsened urban-rural disparity areas in less-developed regions have presented new and serious challenges to China's policymakers.

Apart from the descriptive analysis, a preliminary regression analysis was performed to explore the underlying factors that drive the advancement of narrowing urban-rural disparities in landline telephone penetration and broadband penetration. The results of this regression show that demographic factors such as education and age of the population have significant positive effects on narrowing of urban-rural disparities in landline telephone penetration. In effect, provinces that made greater progress in lowering illiteracy and whose population got younger witnessed greater progress in narrowing of their urban-rural disparities in landline telephone penetration. A wealth effect is also implied in that GDP per capita has a significant negative effect on urban-rural disparity in landline telephones, which suggests that provinces with greater economic growth tended to make greater progress in narrowing of urban-rural disparity in landline telephone penetration. Regarding urban-rural disparities in broadband penetration, however, education was the only significant explanatory factor. The implication of these results is that provinces should emphasize different aspects of universal service programs when aiming to narrow their urban-rural disparities in landline telephone penetration and broadband penetration.

China's top-down model: Is it sustainable?

China has taken a simple approach to the implementation of its universal service program. Universal service is regarded as a contribution by the telecommunications industry to actualize the Socialist Countryside campaign (MII 2004). In the initial Telephone to Every Village program, the government simply distributed the tasks among the country's state-owned carriers, based on their respective revenues, profits, and the geographical locations of their networks. Because China's major carriers are all state-owned enterprises, this straightforward model has proven to be very effective. However,

numerous studies have demonstrated that China's model is uncertain and inconsistent due to the ambiguous roles of government and business and the government-business relations in terms of both regulatory incentives and regulatory governance (Harwit 2004; Liu 2012, 2016b; Xia 2010; Xia and Lu 2008).

While concern for profitability might not be a high priority to the Chinese carriers in carrying out the universal service mandate because its programs are often endowed with ideological and political significance, China's universal service program is at risk of long-term sustainability failure (Liu 2016b). In 2006, the central government began to support some of the maintenance costs of rural telephone networks (MOF 2006).[3] As part of China's national broadband strategy, in 2013, the State Council required the Ministry of Industry and Information Technology (MIIT), the National Development and Reform Commission (NDRC), the Ministry of Finance (MOF) and other concerned departments to expeditiously improve the universal service compensation mechanism, which focuses on broadband, and to accelerate the construction of the rural broadband infrastructure (General Office of the State Council 2015; State Council 2013b). Accordingly, since then, the MOF and the MIIT have annually issued the Notice on Carrying out the Pilot Program of the Universal Telecommunications Service. The current policy states that the central government will subsidize 15%, 20%, and 30% of the construction costs and 6 years of the maintenance costs of the Broadband to Every Village project in the eastern, central and western provinces, respectively. This funding will be awarded through open competitive bidding, and the state-owned carriers are expected to play a major role in the universal service program. To date, the available information shows that no companies other than state-owned carriers have participated in the universal service program. Thus, while some progress has been made in establishing a universal service compensation mechanism, the issue of fundamental financial unsustainability has not been resolved. In China, in addition to the subsidy from the central government, carriers are also encouraged to seek funding support from local governments. In fact, in many ways, China's universal service program is essentially a provincial endeavor (Liu 2012). In addition to the nationwide Telecommunications to Every Village program, many provinces have initiated their own digital divide programs. However, these programs are often criticized for their lack of vision, coherent strategy, accountability, and a sustainable economic model (Liu 2012, 2016b; Ting and Yi 2013). Ironically, richer provinces, which usually have higher levels of informatization, are capable of investing more in the bridging of the digital divide, which, in turn, arguably further worsens the regional divide (Liu 2016b).

Mobile missing in the universal service program

It is widely hoped that the rapid expansion of mobile technology can help bridge the digital divide at a faster rate. Mobile technology is cheaper than traditional fixed line technology for covering rural and remote areas. Further, empirical studies have shown that the adoption of mobile technology is less determined by demographics, socioeconomic status, and technological readiness (Akiyoshi and Ono 2008; Srinuan, Srinuan, and Bohlin 2012; Wareham, Levy, and Shi 2004). However, China's existing universal service programs focus exclusively on fixed-line telephones and broadband. There has been no project on utilizing mobile technology to narrow the digital divide so far. As a matter of fact, China's telecommunications regulator does not collect detailed statistics on mobile communications. In particular, existing official statistics do not distinguish between urban and rural areas in mobile connections. Consequently, constrained by the data availability and the scope of China's current universal service policy, mobile technology had to be excluded from the analysis of urban-rural disparities in this study. This exclusion of mobile in the broadband measurement might have led to an overestimation of the urban-rural divide to some extent because rural residents can still access the Internet via mobile where fixed broadband is unavailable or unaffordable.

Given the strong growth in mobile technology, China's policymakers should consider adding mobile technology to the menu of the universal service programs. In fact, as noted in the previous sections, China's fixed-line market is in decline due to fixed-to-mobile substitution. With the advancement of mobile technologies and the improving affordability of smartphones, it is recommended that China's policymakers take a technology-neutral approach to covering underserved areas and populations in the future. However, it might also be too optimistic to completely rely on mobile technology to bridge the digital divide. In a recent study of mobile phone usage of people in a mid-sized city in southwest China, it was found that rural mobile-only users are the most disadvantaged users in terms of both access and usage. Only 15% of them use their mobile phones to access the Internet and they tend to generate the least amount of mobile Internet traffic compared to other groups (Liu and Wang 2020). In fact, Napoli and Obar (2014) warn that the mobile Internet might create a "mobile Internet underclass." Therefore, it is suggested

that, while it is crucial to keep expanding the network, user-centered programs aiming to promote the effective use of the mobile technology are also essential.

Conclusions

The year 2004 marked the official launch of China's universal service program. In 15 years, China has achieved significant progress in narrowing interprovincial and urban-rural digital disparities, particularly in terms of network capacity. However, the increase in the penetration rate has lagged behind the expansion of the network. Certainly, some of the most remote villages are now connected to the national telecommunications network. However, the urban-rural disparities have remained largely unchanged. The unavailability of infrastructure in rural areas is no longer the most vital concern of China's urban-rural digital divide, particularly with the development of mobile broadband technology. Now, what is at issue is how to attract more individuals to use the network. Therefore, it is recommended that Chinese regulators adopt an expanded range of policy tools, such as education, training, and subscription subsidies, which directly target end-users.

In addition, in the current universal service design, the interprovincial digital divide is largely overlooked. This study shows that the provinces are not making progress at the same rate. Ideally, to achieve balanced development, those less-developed provinces should advance at a faster pace. However, the data analyzed in this have not supported this optimistic expectation. In fact, there seems to be a Matthew effect occurring in the interprovincial digital divide. While the central government has somewhat begun to solve this issue by allocating more funds to the less-developed areas, a new policy mechanism should be designed to incentivize the provincial/local government to more actively participate in universal service programs.

Overall, while China's 15-year universal program deserves much credit, it is now in need of rejuvenation to better meet the current market conditions, as China has now passed the expansion stage and entered the saturation stage. Laying down more fibers and erecting more towers have diminishing effects on narrowing China's digital divide. This is not an easy transition for China's policymakers, who are comfortable with the top-down approach of giving orders to state-owned carriers. However, to achieve a harmonious online nation, as promised by the Communist Party, it is timely and probably more cost-efficient to make this paradigm change henceforth.

Notes

1. The Broadband China campaign comprises of the following four national-level policies issued by the State Council: Notice of the State Council on Printing and Distributing the "Broadband China" Strategy and its Implementation Plan (Guo Fa 2013, No. 31); Several Opinions of the State Council on Promoting Information Consumption to Expand Domestic Demand (Guo Fa 2013, No. 32); Guiding Opinions on Accelerating the Construction of High-speed Broadband Network to Increase Internet Speed and Cut Service Charges (Guo Ban Fa 2015, No. 41); and Guiding Opinions of the State Council on Further Expanding and Upgrading Information Consumption to Constantly Release Domestic Demand Potentials (Guo Fa 2017, No. 40).
2. BDA is an association of China's major broadband service providers. BDA conducts research on broadband development, policy, and standards.
3. The amount of funds available has not been made accessible to the public, and no scholarly research has been conducted on the details of how the funds are distributed. According to an interview published on the central government's official website, the Director of the MIIT's Research Institute of Policy and Economy told a reporter that the annual subsidy from the government was around 400 million RMB, which can barely cover the maintenance cost of the Telecommunications to Every Village program (See: http://www.gov.cn/zhengce/2015-10/15/content_2947213.htm).
4. An administrative village is the lowest administrative body in China's hierarchical government system in rural areas. An administrative village might comprise one or more natural villages – defined as a rural community consisting of over 20 households.

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